A TEXT-BOOK

OF

UROLOGY

BY

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THIS BOOK

IS AFFECTIONATELY DEDICATED TO THE MEMORY OF

WILLIE ANN SWINNEY LOWSLEY

MOTHER OF ONE OF US AND DEAR FRIEND OF THE OTHER

AND TO OUR WIVES

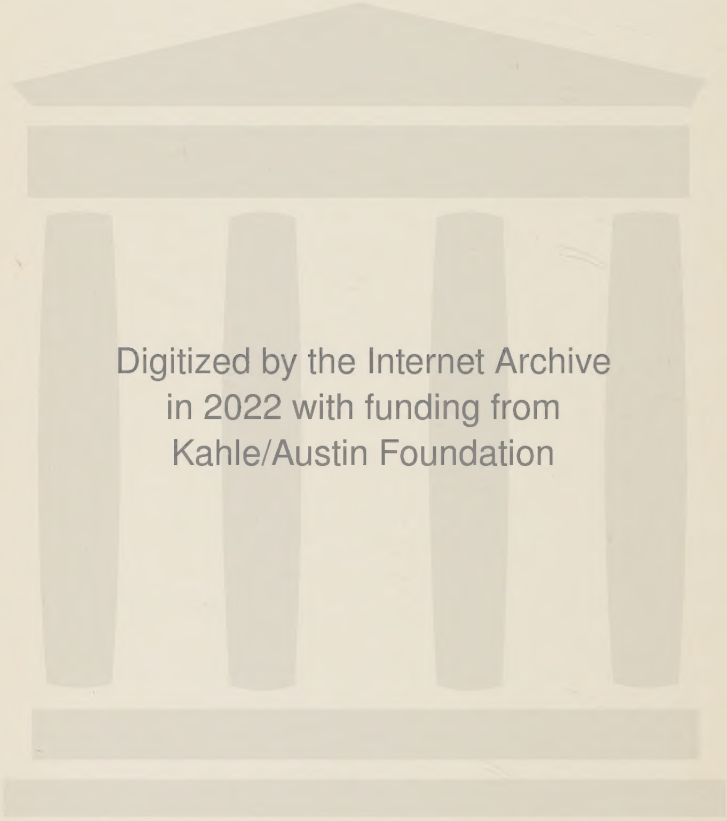
MARGARET HUGHES KIRWIN

AND

ELDIVA BROWN LOWSLEY

IN APPRECIATION OF THEIR UNFAILING LOYALTY,

DEVOTION AND ENCOURAGEMENT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PREFACE.

This text-book is based upon eighteen years of intensive study which its authors have devoted to laboratory research and clinical experience in the hospital and private practice of surgery of the genital and urinary organs. Good fortune has favored them with unusual opportunities for observing the methods of the masters in their own and in many foreign countries. These advantages have been supplemented by their constant review of the vast literature which recent years have brought forth. Therefore, the most difficult task with which they have been confronted has been that of the reduction of this great mass of widely derived information to the dimensions of a practical text for students and practitioners.

Considerable economy of space has been effected by reducing the historical background to a single introductory chapter; and by following it with another upon the general Diagnostic Procedures of Urology. Beginning with Chapter III, the parts and organs are considered in their anatomical sequence from without inward. The embryology, morphology and anomalies of each are followed by a succinct but clear presentation of the injuries and diseases, with the most approved methods of diagnosis and treatment. Only such operations as have passed the test of personal experience have been given in detail. These are described as accurately as possible, and illustrated in many instances with drawings and photographs. The purpose of the authors has been to construct a complete text-book in one volume. It has been impossible to mention each writer on every subject, but a special effort has been made to include the most important references in the bibliography at the ends of the chapters. This makes it possible for the serious student to look up original articles whenever desired.

It has been found that regional anesthesia is useful for operations upon every organ of the genital and urinary tracts. Attention is called to the methods employed by the authors, who are among the pioneers in this field in America.

With a moderate number of exceptions, the illustrations are all

original, and are chiefly derived from researches or patients of the authors. It is hoped, that the illustrative feature, taken in correlation with the text, will add much to the lucidity and value of the work. Special mention must be made of the delightful work of the late Dr. E. Desnos, the distinguished French urologist, and of the courtesy of his publishers, A. Doin & Son, in permitting the use of illustrations and material from his unequalled monograph upon the history of urology, now for the first time made available to those unfamiliar with the French language. Professor E. Christeller of Virchow's Krankenhaus, Berlin, has been so kind as to allow the use of several colored plates which demonstrate his new technic of freezing entire organs for microscopic section. By this method he is able to eliminate the weeks of time-consuming effort heretofore required in the preparation of specimens for examination.

Much of the earlier work which now serves as a basis for this text was carried out by the authors when they were members of the Urological Staff of Bellevue Hospital, under the directorship of Dr. Edward L. Keyes, Jr. and Dr. Alfred T. Osgood, to whom grateful acknowledgement is hereby made. Later work in the Department of Urology (James Buchanan Brady Foundation) of the New York Hospital has contributed to the elaboration of numerous subjects. For this, and for the invaluable assistance of all their colleagues of the New York Hospital, the authors owe a large measure of gratitude.

The authors also feel very strongly that special mention should be made of the wonderful foresight displayed by the late James Buchanan Brady, who showed himself a real friend of suffering humanity by his establishment of the Department of Urology at the New York Hospital. The ample means bequeathed for the conduct of its activities will remain as a living monument to his generosity and innate kindliness. The sustained interest of his executors, R. C. Crowley and R. L. Gordon, with the active and hearty coöperation of the authorities of the New York Hospital, led by its president, Mr. C. W. Sheldon, insure the fullest possible benefits from this great gift for the advancement of the practice of urology.

Finally, thanks are extended to Mrs. Amy Pope Shirk for help with translations and for literary research, and to the Publishers for their courteous patience.

O. S. L.
T. J. K.

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TEXT-BOOK OF UROLOGY.

PART I.

INTRODUCTION AND HISTORY.

CHAPTER I.

FOREWORD.

Urology, in the sense in which we use the word today, was not recognized as a definite entity apart from general medicine and surgery until the nineteenth century was well advanced. Hardly a dozen years ago we find in the literature entire articles devoted to a discussion of whether or not urology was entitled to be regarded as a speciality, and even today the position of the urologist, as distinct and apart from the general abdominal surgeon and the syphilologist, is by no means universally recognized. Yet we must remember that however necessary or desirable is the attendance of a skilled urologist, it is by the general practitioner that by far the greater number of genito-urinary cases are first seen, and it is only by his intelligent appreciation of the importance of pathological conditions in that region, that the vast majority of patients can receive any measure of relief. The value of a comprehensive knowledge of the basic principles of urology and the application of practical methods of diagnosis and treatment can, therefore, hardly be over-estimated, and the necessity of equipping himself with such knowledge should be impressed upon the mind of every student of medicine.

Conversely, no practitioner should ever attempt to become a specializing urologist without first obtaining, both by study and in the hard school of experience, a thorough knowledge of general surgery and internal medicine, and the reciprocal relations that the special organs, to which he intends to devote his professional attention, bear to the rest of the body, both physiologically and anatomically. The recent advances in the study of focal infection have done much to demonstrate how closely one "specialty" may be allied to another, and the possibility of tracing the origin of such widely divergent morbid states as a disordered memory or a painful great toe, to the same decayed tooth or septic tonsil, has emphasized the importance of broadening every special field as much as possible, and likewise of increasing the coöperation and interchange of knowledge between medical practitioners of every sort.

The marvelous progress made in urology during the last few years has been due in large measure to the introduction of improved mechanical equipment; the perfection of the microscope, with the vast increase of bacteriological knowledge which it has permitted; the use of anesthesia, both general and local; the advances in chemistry, which, together with the microscope, has made possible the existing accuracy of urinalysis, and perhaps most important of all, the artificial illumination of the bladder, with the development of cystoscopy and the use of the roentgen-ray.

It is not too much to say that urological diagnosis now rests almost entirely upon the findings of the microscope, the cystoscope and the roentgen-ray. He who is able to make an intelligent application of all of these three mechanical aids, is equipped to locate, recognize and classify practically any lesion or abnormal condition in the genito-urinary tract.

By a diligent use of the microscope can be detected the presence of bacteria, or any other abnormal constituent of the voided urine; through the cystoscope any irregularities in the bladder become visible, and cysts, tumors, ulcers, calculi, foreign bodies or prostatic obstructions, edema or inflammation of the mucosa can be recognized; by radiography and fluoroscopy, diverticula, dilatations, tumors and calculi, are frequently revealed.

The presence of stone can usually be demonstrated by roentgen-ray examination of the urinary system, and the shape and position of the kidney can be outlined. In conjunction with ureteral catheterization the internal condition of the kidney can be visualized by distention of the renal pelvis with a shadow-casting medium injected through the catheter. By this method of examination one may gain information as to the capacity of the renal pelvis, as well as its contour, size and internal arrangement; in the presence of neoplasm, it is also possible to judge whether the ureter outlet is so situated that drainage of the pelvis is taking place.

When one combines the use of these three mechanical agents, their assistance is even more valuable. The cystoscope and roentgen-ray together will often demonstrate the existence of hydronephrosis, "wandering" kidneys, angulations and impactions of the ureters, and many other conditions impossible of detection by the use of one alone; while the chemical and microscopical findings will serve to illuminate any ambiguities in the previous observations.

By the passage of catheters to both kidneys, so that the urine from each organ is separately collected, it is now possible to demonstrate unquestionably the site of a lesion which may be the source of the abnormal elements previously detected in the voided urine. Thus the most important information may be derived from inspection, not only of the gross appearance of each catheter specimen, but by analysis and cryoscopy of the separated urines.

In addition to these mechanical aids the tests of renal function now take a rank of first importance in urological diagnosis.

By subcutaneous or intravenous injection of certain dyes, the functional activity or efficiency of either kidney may be ascertained by an estimation of the organ's ability to eliminate the dye. The use of these tests enables the physician to arrive at a decision as to the possibility of removing one kidney if the results of the test indicate that without it enough functionating renal tissue will be left to make continued existence possible; as to the wisdom of performing any operation, renal or otherwise; or, in the case of a renal operation, as to its nature and extent. In the medical treatment of nephritis, these tests have proved of great value in revealing the degree of the existing renal impairment, and are also useful in the consideration of possible operative intervention upon the prostate.

It is evident that for the practice of urology, whether as a specialty or merely in the course of more general work, familiarity with many diagnostic methods, and high technical skill in the use of mechanical apparatus, is a major essential. The importance of genito-urinary symptoms is only just beginning to be recognized, and it should be emphasized that no urogenital disorder should ever receive merely symptomatic or empiric treatment. There is a definite cause for every symptom, and justice to the patient, to say nothing of standards of professional efficiency, demand that the cause be definitely determined.

There is still another aspect of urological practice which must be considered by everyone who undertakes it, whether it be as a life-work, or merely as a side issue to something else, concerning which, Hugh Cabot, speaking of the training of the urologist, has said:

"Social unrest arising from inequalities in the social scale is the most important present phenomenon of our civilization. More and more, thinking men are realizing that this is not the chatter of cranks, but a failure in our development that will require the full application of the best minds for its solution. No group of men is brought more constantly into contact with these problems than physicians. No one of these problems is more difficult and far reaching than that of the relation between the sexes, involving as it does, not only the whole question of marriage and divorce, but also the various diseases and disabilities arising from the relation. In no department of medicine do these questions confront the physician with more force than in urology. Any man who takes up this work will find himself deeply involved in these problems. He cannot well plead as an excuse that his duty begins and ends with the treatment of disease. It is all too clear that more and more demand is being made on the physician for expert advice in preventive medicine, and he must either fit himself for this work or give up his job. The future urologist must devote time and study to social questions that he may help to guide a public opinion that is now fully aroused to their importance and anxious to apply a remedy. He will need to bring to these questions the best that his mind affords, for they are intricate, involve time-honored – if 'shop-worn'—moral standards, and arouse passionate defence of long-standing—if imaginary—rights."

CHAPTER II.

HISTORICAL REVIEW OF THAT BRANCH OF MEDICINE CALLED UROLOGICAL SURGERY.

Though we are in the habit of considering urology as a "new development" in the art of medicine, owing no doubt to the fact that some of the most recent additions to the physician's equipment, such as the diagnostic use of the roentgen-ray, have found their widest application in this field, as a matter of fact the practice of urology is among the oldest, if not actually *the oldest*, of all attempts of man to heal disease, and it is probable that the very first surgical operations every attempted were those upon the urinary tract.

India.—Ancient Hindoo Literature.—In ancient Hindoo literature, so ancient indeed that its precise dates are wholly unattainable, but certainly written down at least a thousand years before the birth of Christ, we observe indications of a lively interest in this particular branch of medicine. In the Ayurveda, the last of the Vedas or sacred books, is recorded the medical knowledge handed down from the gods themselves by their physician Dhavantari, to Sucruta, who made avilable to common mortals certain prayers and incantations, together with hygienic instruction concerning fecundity, pregnancy, and especially causes of retention of urine. With these theological instructions we find also some sidelights on physiology. It appears that when man drinks water the fluid is resolved into several elements; the coarsest portion goes to form the urine, the finer elements the blood, and the most rarified portion of all is exhaled in the breath.

Sucruta.—Sucruta was probably an editor or compiler of lore which had come into existence long before his time. The actual period at which this diligent therapist lived has always been a matter of dispute among scholars and archeologists. Hessler, who made the first translation of his writings, placed him about 3000 B.C., while Haas, who went over the ground more recently, ranked him among the effete moderns of the year 1000 A.D. Sucruta's very existence has been questioned; it has even been argued, and with a good show of logic, that his name is nothing more that a corruption of Socrates, whom the Arabs frequently confused with Hippocrates, and that Kaci (Benares) where he was said to have lived, can be identified with Cos, the Grecian island which gave birth to the "Father of Medicine."

Diseases of the Urinary Tract. Be this as it may, we still are able to find in this undoubtedly ancient compilation, many references which give evidence of extremely early urological practice. In *Madhumoha*

("honey urine") we readily recognize diabetes mellitus, with its carefully described symptoms of languor, thirst and evil-smelling breath; and in the long list of surgical instruments, descriptions of the forerunners of our modern sounds, trocars, bougies, catheters, and even a rectal speculum, are fully set forth. Lithotomy is described, likewise the correction of omental hernia through the scrotum. We find too, dissertations upon the etiology of stone, and rules and exhortations for its removal. To alterations in the urine many ills are attributed, and it is possible to make out a recognizable symptom-complex from certain of the descriptions found here; nausea, vomiting, extreme languor and somnolence are associated with certain macroscopic aspects of the urine, and pains in the region of the penis and testicles are attributed to the presence of renal and vesical calculi. Though the chief reliance of the ancient Hindoo physician was in herbs and strange decoctions of mineral and animal substances, we find occasional directions in regard to diet which show less reliance upon the occult, and more upon observation and common sense. Those who suffered from stone must refrain from eating meat and live exclusively upon a vegetable diet. The patient must take suitable exercise, and this is advised according to his social and financial state, very much as we might give the same advice today. The rich man may go boating, horseback riding, or promenading in the garden; while the poor man will find his condition much improved by walking barefooted in the sun for a goodly distance.

Instrumentation Among the Ancient Hindoos.—Urinary surgery is definitely recommended and its practice described. The *Instrumenta tubulata multipliciter adhibenda* of Hessler's translation are undoubtedly sounds which were used to reduce tumor of the abdomen due to retention of urine. If such a tumor appears in the scrotum it is first to be treated by hot applications; these failing, the surgeon perforates the left raphé, introduces a hollow tube and draws the urine off, finally closing up the incision with a ligature. Whether this description is of a perineal infiltration, or concerns mere catheterization, is not clear.

Stones should be induced to pass by internal medication and external applications, aided by the employment of hooks and crochets if so located as to be accessible; should these milder means bring no results, cutting may be employed, but it is pointed out that it should never be regarded as anything but a last resort; if death is certain without it, then by all means let it be tried, but the prognosis is at best, a very poor one. If all the omens are favorable, the patient disembarrassed of all evil spirits by the proper exorcisms, and suitable religious ceremonies duly completed, the physician should begin by offering all possible encouragement to the sick man. He should then seat him upon a suitable operating bench and securely tie his arms and legs. The abdomen is anointed with oil and strong pressure exerted upon the left side of the umbilicus until it is possible to palpate the stone. The surgeon's finger, with nails well trimmed and thoroughly lubricated,

is now introduced as far as possible up through the anus, while the other hand endeavors by external pressure to approximate the reach of the internal fingers, so that the calculus may be pushed downward to them. If one can thus touch the bladder, the stone may be shelled out as one would a nut. Should the patient faint when the calculus is reached, it is useless to continue the effort, for he will surely die, but if his fortitude is sufficient, the extraction may be brought to a triumphant conclusion. A scalpel of a size proportionate to that of the calculus is selected, a small incision is made, and the calculus withdrawn with pincers. The greatest care must be taken not to break, or even to scratch the stone, for should the slightest grain of its dust remain in the wound it will serve as a nucleus for another stone. The operation completed, the patient should be placed at once in a warm bath and made to perspire freely.

The surgeon is fully warned as to the necessity of selecting the site of incision with all due regard to the anatomy of the parts involved. Should he cut the source of urine (ureter) death will inevitably result; if the spermatic canal is severed, impotence or most likely death will ensue; virility will be lost if the testicles are injured, and damage to the urethra will cause incontinence of urine.

Desnos remarks that the similarity between this meager description and the operative details which Celsus gives in his account of the same malady, is very striking, but that this does not necessarily indicate that the operation of cutting for stone came to the Hindoos from the Greeks, nor does it in any way enlighten the vexed question of Sucruta's dates. We must remember that in all probability, the works of both Sucruta and Hippocrates were but compilations of knowledge commonly held long before their time, and the Hindoo and Greek systems of medicine may both have drawn such knowledge from a single source back before the time when such lore was first committed to writing.

Egypt.— Whether the medical knowledge of the Egyptians antedated that of the Hindoos, we have no accurate means of judging. The researches of Egyptologists do not throw any light upon the subject of early operations for the removal of calculi, perhaps because, even today, the upper classes in Egypt are not subject to lithiasis, and among 9,000 mummies, only the bodies of the well-to-do being embalmed, but two renal calculi have ever been found, and not a single perineal or hypogastric scar indicative of operative interference, has ever been observed.

Circumcision.— However, we have abundant evidence that the Egyptians freely practiced at least one urological operation, that is, circumcision. There is, in the Cairo Museum, a sculptured figure of a Pharaoh, upon whom the evidences of circumcision can plainly be seen, and on the tomb of Ankh-ma-Hor, dating from the fifth dynasty, approximately three thousand years before the beginning of our era, there exists a relief showing the procedure of circumcision in all its details. The operator is evidently a priest, for its plain that the operation was a religious rite and not, as has been frequently supposed, a hygienic

measure. It is noticeable that in other reliefs that decorate this tomb, several of the figures are represented as having been circumcised.

Like the Hindoos, the Egyptians regarded the genital organs as the center of life and therefore, the most precious part of the body, an offering from which would be a sacrifice peculiarly satisfactory to a deity. Among the Hebrews and other ancient peoples who came under Egyptian influence, in making oath a man placed his hand between his thighs, thus resting it upon the most sacred symbol known to him.

Ebers Papyrus.—Practically all that we know concerning Egyptian medicine is contained in the Ebers papyrus, which is the most complete exposition the world possesses of the medical science of any ancient civilization, but unfortunately it contains but few references relating to urological matters. Though occasional prescriptions are given for controlling a too-free flow of urine, or for making the urine flow when obstructed, or again for "abating pains in the lower belly," there is little else which is of especial interest to the student of ancient genito-urinary lore. There are no evidences in the Ebers papyrus that Egyptian medicine, though infinitely older, had any influence upon the Greek, or that the diseases there described were the same as those which Hippocrates observed and treated, though it is not at all unlikely that they were. The medical tradition of Egypt seems to have undergone no changes, nor to have made any advance, until the invasion of Alexander brought about the Hellenization of all intellectual activity in that country, an event which found its outward manifestation in the foundation of the School of Alexandria. When the medical centers of Cos and Cnidus began to send their students into Egypt, there was a new life infused into the ancient methods which for so many centuries had endured upon the banks of the Nile, but from that point the urological practices of Egypt become one with those of Hippocratic Greece.

Urology Among the Ancient Hebrews.—The medical procedures of all Semitic peoples are closely analogous. From the Bible we learn how great was the influence of Egypt upon the national character and customs of the children of Israel. Yet the Bible gives us but little insight into the medical history of the Hebrews, and we have practically no references to anything connected with that part of it which relates to the genito-urinary tract, except the frequent allusions to circumcision, and the hygenic laws enacted against certain sexual practices common to the other Semitic tribes.

The Talmud.—In the Talmud however, which is essentially a law book and not an historical compilation as is the Bible, there is much medical information to be gleaned from the regulations regarding conduct and diet with which this code especially concerns itself. The fact that all animals slain for food were carefully inspected before being eaten, to determine whether they came within the requirements laid down in the code, gave the Hebrews opportunity to study anatomy and pathology, at least in their postmortem aspects, which was not

enjoyed by the Greeks or other early peoples. They were tolerably familiar with the arrangement of the organs, and with certain of their functions, and there is abundant evidence that they applied that knowledge in their treatment of human ills.

Diseases and Operative Procedures.—Several descriptions of urological affections seem to indicate that they suffered afflictions not unlike those of our own day and generation. Blennorrhagia is unmistakably described, and the retention of urine due to the formation of calculi was understood and intelligently treated. There is no evidence that the ancient Hebrews "cut for stone," but the operation for imperforate anus was done, and pathological renal conditions were recognized and their gravity fully comprehended. It is possible also to identify among the instruments mentioned and used, the forerunners of the modern speculum and uterine sound. But in general, the ancient Hebrews were hygienists rather than physicians or surgeons; the eminence attained by this people in the field of medicine was a development of the later period of their history.

Greece.—Early Greek Medicine.—Much concerning the beginnings of Greek medicine has been unearthed by diligent students of medical history, but it is not until the age of Hippocrates that we find much of interest along the lines of urology. In the writings of the Father of Medicine, the lore of past centuries was carefully incorporated, so doubtless a great deal of what we learn from them had its origin much further back. We know that long before Hippocrates was born, the art of medicine had taken its place among the other arts, and the physician was an honored member of the community, so it is probable that the practice of urology, perhaps even as a specialty, set apart from the treatment of other ills, had received its full share of attention.

Hippocrates.—Hippocrates was above all things a clinician. Inasmuch as dissection of the human body was regarded with horror by the Greeks, anatomy and physiology were but vaguely comprehended, and any degree of scientific accuracy was impossible. But in Hippocrates we find the keen insight developed by long and careful observation, combined with a wonderful clarity of vision and breadth of view, and above all, an unexcelled ability for "putting two and two together." Of actual pathological conditions he often knew but little, and of etiology he was still more frequently ignorant, but his keen observation and critical judgment are continually in evidence in the descriptions he gives of various maladies, and the intelligence with which he sets forth rules for their treatment.

Urinary Calculus.—Of calculus formation he undoubtedly made a careful study, and although his conclusions are wholly theoretical, his keen mental faculties conducted him very close to the truth:

"Stone, gravel, strangury, sciatica and hernia occur frequently in those regions where the inhabitants are forced to drink waters of a certain nature. Those whose bellies are free and sound, who have no burning in the bladder, nor the neck of that organ closely retracted,

easily evacuate all their urine, so that nothing has opportunity to condense in the bladder. But when the belly is hot, then the bladder becomes overheated beyond all natural limit; its neck becomes inflamed and the urine being unable to pass out entirely, that which remains is exposed to the action of this excessive heat. The lighter elements flow out, but those that are heavier sink downward, becoming ever more thick and solid. The nucleus of the stone grows progressively, for by the movement of the fluid urine in the bladder, it is constantly augmented by additions from the solid elements which are deposited below, thus increasing steadily in size, and growing ever more hard. At last this calculus becomes lodged in the neck of the bladder, stopping the outflow of urine, and causing the most excruciating pain.

"In children, especially infants, it is the greater heat of the bladder and of the entire body which leads to the formation of calculus. Its origin is in the milk upon which the child is nourished. If this milk contains anything impure it will lodge in the bladder and when the remainder is absorbed, will become a stone, which in course of time is so augmented that the pain caused by its passage will hinder it when it might be carried out with the outflow of urine.

"Those afflicted with calculus, if they place themselves in such a posture that the stone will not block the orifice of the bladder, will pass their urine without difficulty; but for those in whom the stoppage of urine is due to a tumor near the bladder, there will be suffering, no matter what postures they may assume.

"If the urine is full of sand, the bladder is likely to contain stone; it is obvious that where the urine deposits gravel there is a predisposition to the formation of stone; nevertheless it is not exact to say that such a one is already afflicted with stone, only that he will be more prone to it than another, in whose urine no sand is seen.

"Of this disease there are five signs: (1) Pain, when the impulse to urinate appears; (2) emission of the urine drop by drop, as in strangury; (3) bloody urine, as the bladder is ulcerated by the irritation of the stone; (4) inflammation of the bladder; (5) the emission of gravel in the urine.

"If a stone has already formed, the occurrence of gravel in the urine may give rise to another instead of increasing the size of that which is already there; thus two, or many more stones may often be found. These, striking one against another, may give rise to still more gravel which the urine will carry out of the bladder."

The dictum of Hippocrates—perhaps one of the best known of those attributed to him—*I do not cut for stone; this work I leave to those whose business it is to do this*—has been a subject of surprise and comment to all those who have studied his works. This no doubt, greatly influenced the prejudice against surgery, which for so many centuries held sway in Europe. But that Hippocrates—or at least those who followed his teachings—performed other operations, there is abundant evidence.

Renal Diseases. In the treatises on diseases and internal affections which have come down to us in the Hippocratic collections, we find descriptions of four forms of renal affections:

In the first there are acute pains in the loin, the groin, and through the testicle upon the affected side; at first urination is frequent; then it is gradually suppressed, and in being passed the patient experiences much pain in the urethra. To relieve this distressing condition warmth should be applied externally, and a purge of antimony administered. If the pain be very severe, an enema of warm water should be given. Should a tumor form, an incision must be made over the kidney, and the pus allowed to flow out; this is a grave operation, but without it, death is inevitable, while performing it offers some small chance of recovery.

The second renal disease described begins like the preceding with violent pains. At the outset blood appears in the urine, which as the disease progresses is mingled with pus. If the patient remains at rest, the cure will not be long delayed, but if he be permitted to move about, his difficulty will be infinitely increased. When pus fills the kidney, there will be a tumor near the spine into which a deep incision can be made. This may lead to a speedy cure, or it may make a wound which will not close but will contract around its edges until the kidney is even more greatly filled with pus. At times this may be evacuated by the rectum and the patient will recover, but if the affection crosses to the second kidney death is almost sure to follow. To combat this evacuants are to be used and the same diet and regimen as were prescribed for the first renal condition. This form of kidney affection frequently terminates in a renal phthisis.

In a third form of renal disease the urine resembles the juice from roasted meat; black bile flows into the kidney, is arrested there in the veins which traverse it, and causes ulceration both of the veins and of the kidney substance itself. The outflow resulting from this ulceration is mingled with the urine. Pain is experienced in the limbs, in the bladder, in the perineum, and even in the kidney itself at times; these pains now and again cease, only to be renewed with even greater violence. The treatment is to evacuate the belly with epithymum or scammony, at the same time making hot applications upon the outside. The diet must be bland and relaxing, with diluted milk and wine mixed with honey.

The fourth renal disease is due to excess of bile or of phlegm, also to excessive sexual indulgence. There are pains in the limbs, in the flanks, and the patient is unable to lie upon the unaffected side without suffering great anguish. Lying upon the belly, he has no pain. The feet and hands are always cold, and the scalding urine is always thick and heavy with a reddish sediment, being passed with pain and difficulty. Sometimes after the passage of a year's time, a tumor will form as in the other affection, and this may be incised and the pus evacuated.

The first of these descriptions corresponds fairly well to renal colic

with or without the passage of calculi; the second is more difficult to recognize, but may very well be one of the forms of kidney suppuration frequently encountered at present. In the initial hematuria and intermittent pain there is a suggestion of renal tuberculosis, or perhaps pyonephrosis with distention. The irradiating pains and abundant hematuria of the third condition detailed might very well concern a condition of far-advanced malignancy. The fourth is the most difficult to identify with any renal condition familiar to modern physicians. The influence of posture upon pain suggests a hydro- or pyonephrosis, but the description of the appearance of the urine would rather be characteristic of tuberculosis or an infected lithiasis.

Rome. –Celsus.—After the era of Hippocrates we find little in the story of Greek medicine that relates to urological practice. The rise of the Alexandrian school transferred to Egypt the medical activity of that age, and it is in the works of the later Roman writer, Celsus, that we must look for information concerning the progress made up to the beginning of the Christian era.

Celsus gives us excellent descriptions of operations for phimosis, urethrotomy and lateral lithotomy, and though in the main he follows Hippocrates closely, we are able to detect a marked advance in the science of medicine during the four hundred years which lay between these two writers.

Rufus of Ephesus.—It is to Rufus of Ephesus, a Roman who lived during the reign of the Emperor Trajan, that we owe the first monograph on the urine. This treatise—*De vesicæ rerumque affectibus*—was preserved to posterity through the writings of Ætius, all Rufus's other medical writings having perished. The section devoted to anatomy is full of the faults common to Roman treatises of that epoch, but in the domain of pathology we find a return to the more intelligent conceptions of Hippocrates. Vesical and renal hemorrhages are described, the latter being attributed to weakness of the kidney which leads to rupture of the veins; the size of the injured vein decides whether the evidence consists merely of a trace of blood in the urine, or of large clots. His descriptions of what he terms nephritis seem, in the light of modern knowledge, to be more probably those of a calculous nephrosis; he believed it to be caused by "corrupt humors" of the blood, by trauma, or by excessive sexual indulgence.

Roman Surgical Instruments.—From another source we can glean some information about the state of urological knowledge and practice among the Romans. By no means the least interesting of the implements recovered in the excavations at Pompeii are those taken from what has been designated as the "surgeon's house," now preserved in the Naples museum. Among them are several sounds of varying sizes, the largest having a double curve very similar to those of modern make. Though made of bronze it is very light in weight and still retains some of the original polish with which it was carefully finished nearly two thousand years ago. Another, the tip of which is

lacking, is designed for use upon a female patient; while the exact purpose to which a third was dedicated is a matter of doubt. As it is pierced by numerous holes, it may possibly have been used in operations upon vesico-vaginal fistulæ.

Votive Offerings.—Still another relic of Roman urological knowledge has come down to us in the votive offerings frequently recovered about the ruins of temples and shrines where the worship of Æsculapius or of Hygeia was carried on. The sick made offering to the deity of terra cotta representations of their affected organs, either when desirous of a cure, or as a thank-offering when the cure had been accomplished. This custom probably existed among the Romans and Greeks in the remotest antiquity, so it is impossible to assign any definite dates to those specimens which have come down to our time. It would appear that votive images of the generative organs, both male and female, were more numerous than those of any other parts of the body. It is probable that representations of the normal penis may have been presented as thank-offerings for posterity obtained. Many have been found however, which plainly show the prepuce distended and inflamed by blennorrhagia or balanitis. The great number of these still existing gives us an idea of the frequency of venereal diseases among the ancients.

A clear representation of hydrocele is shown in a greatly mutilated terra cotta figurine found near one of the temples of Hygeia.

The Middle Ages.—The decay of ancient civilization plunged the science of medicine into obscurity, and throughout the Middle Ages we find but little that relates to the history of our subject; and even this is but a repetition, often badly mutilated in the re-telling, of the technic of the classic period.

Decline of Surgery.—In the seventh century we find Paul of Ægina in his description of herniotomy recommending the removal of the testicles, and this inexcusable mutilation was perpetuated by the Arabians and by the itinerant "beggar surgeons" of Europe for more than nine hundred years. During the Middle Ages all surgery fell into disrepute, and its general practice "including most of the major operations, was, in the end, relegated to barbers, bath-keepers, sow-gelders and wayfaring mountebanks," and the surgeon came to be regarded in such a menial light that even in Prussia, up to the time of Frederick the Great, it was still one of the duties of the army surgeon to shave the officers of the line. Lithotomy and herniotomy were performed by those "barber surgeons," and it is but seldom that we find this branch of medical art even recognized by the physicians of the period.

Itinerant Surgeons.—"Cutters" or "incisors" were the names applied to those surgical practitioners, the "wandering mountebanks" already referred to, who traveled about Europe during the medieval period. Those who operated for hernia and lithotomists were considered as of a higher grade than those who set bones and dressed surgical wounds.

Their store of professional lore was carefully preserved and handed down secretly from father to son. "Another group of these traveling operators was known under the name of Norsini. These devoted themselves principally to operations for hernia and to lithotomy. Fabrice d'Aquapedente mentions Horace of Norsia as a skilled operator in hernia. Sylvaticus in 1601 complains that the operation of lithotomy was abandoned to ignorant persons, like the Norsini. In 1633, Cortesi writes that at Messina he had seen Ulysses of Norsia treat hernia by the application of caustic, followed by incision of the eschar; and still later, in 1672, Bernardino Genga says that the Norsini had some experience in the treatment of diseases of the urinary organs."

Ambrose Paré.—The greatest surgeon of the sixteenth century, in the field of urology as well as in other domains, was Ambrose Paré, originally a blacksmith, later a barber's apprentice. When twenty-two years old he came to Paris and there was fortunate enough to receive whatever surgical instruction was then available, and also to serve in the Hôtel-Dieu as a student practitioner. Becoming a master barber-surgeon in 1536, he was attached to the army which Francis the First led into Italy during the following year, and it was upon the battlefield and in the army encampments that Paré obtained the skill and knowledge that made him the first surgeon of his age.

In his *Surgery*, first published in 1564, we gain considerable enlightenment concerning this master's practice in handling genito-urinary diseases. Though the reduction of strictures by the passage of sounds did not by any means originate with him, he seems to have been one of the first to apply common sense methods to the treatment of such conditions, and he was certainly the first to recognize hypertrophy of the prostate as a cause of strangury. That he devoted himself especially to this branch of surgery is evidenced by the fact that to the third edition of his *Surgery* he added three more books, "on gonorrhea, on stone, and on the retention of urine."

Beginnings of Lithotomy.—In 1535 Marianus Sanctus published at Venice a treatise—*De lapide ex vesica per incisionem extrahenda*—in which was written down for the first time, the method of John de Romanos of performing lithotomy with the grooved staff. In this technic an incision was made into the membranous portion of the urethra, after which instruments were introduced to dilate or rupture the prostatic portion. This method was known as that of the greater apparatus—"grand appareil"—from the number of instruments required, and also as the "Marian operation" in honor of him who had first committed an account of it to writing.

"Petit" and "Grand Appareil."—Thus at the beginning of the sixteenth century the ancient mode of extracting calculi, practiced from the time of Hippocrates, gave place in large measure to this more difficult and complicated procedure. Thereafter we find simple extraction according to ancient practice designated by the French term *petit appareil*, while the method of John de Romanos—or to give him his

native appellation -Giovani di Romanis, a physician of Cremona, was called by the more high-sounding name.

We learn from a letter which Giovani wrote to Marianus Sanctus that the idea of employing the grooved staff first occurred to him as a means of overcoming the difficulties encountered in finding the vesical neck when dealing with a little child. To obviate this, he introduced into the urethral canal a sound which served to assist him in reaching the bladder. He improved his manner of doing this as time passed, likewise devising several new instruments, and, as we have seen, his work was further improved and extended by Marianus, who was his pupil and successor.

Lithotomy of Marianus Sanctus.—The patient was placed upon a table, with the head elevated, and the thighs widely separated and held in this position by assistants. A grooved sound called the *itinerarius* was introduced into the urethra and the stone located through the perineum. The surgeon now made his incision to the left of the raphé, the size of the cut being regulated according to the age of the patient or the dimensions of the stone, the instrument used for this purpose being a sort of scalpel called the *novacula*. The tissues were divided as far as the bladder neck, care being taken to avoid severing the sphincter, as this would lead to incontinence. Another instrument called the *exploratorium* was now inserted in the grooved cannula, which in turn served as a guide to the two *ductores* which were separately introduced. The canal was then dilated by the use of the *aperiens*, and with the conductors still in position, the *forceps* was brought into play to seize and withdraw the stone. Should any débris remain in the bladder, it was scooped out by means of the *cochlear*. The fact that such an instrument as this last-mentioned existed would seem to indicate that it was frequently necessary to crush the stone while still within the bladder, but Marianus, though he describes the *frangens*, a crushing forceps, especially deprecates its use, and evidently regarded fracture of the calculus as an accident to be avoided whenever possible.

Successors of Marianus. The work of Marianus Sanctus was carried on by Pierre Franco and later by Fabricus Hildanus and Fabricus d'Acquapendente. In the seventeenth century *le grand appareil* was advocated or practiced by François Tolet, whose *Traité de la lithotomie* was first published in 1681 and ran through six editions; by Johannes Jacobus Rau and by Morand.

Pierre Franco was the most famous of the "incisors" who flourished during the sixteenth century. In a treatise on the art of surgery which was made public in 1556, he described a sound for the detection of stones in the bladder which he called *algalie*, and likewise mentioned in discussing its use, that stones are at times so encysted that they cannot be felt. He gave descriptions of the operative procedures of his predecessors, as well as some he himself had previously undertaken to accomplish the same end which he now sought with his new

instrument. He gave several figures of other instruments, among them a forceps useful for crushing a large stone in order to facilitate its removal. If the stone does not come into view immediately the incision is made, it is, in Franco's opinion, wiser to wait a day or two before making another attempt to extract it. He gives a case report, the patient being a child, aged ten years, where failing to reach the stone through a perineal incision, he did a suprapubic operation, apparently the first suprapubic cystotomy ever performed.

Nephrotomy.—Nephrotomy is said to have first been carried out by Dominique de Marchetti, who succeeded his father, Pietro, as professor of surgery at Padua, in 1662. The operation was successful, despite the fact that he did not have the "tumor" mentioned by the Greek and Roman writers, to serve as a guide by which to make his incision. But it was in France, rather than in Italy, that progress was made during the seventeenth and eighteenth centuries. Frère Jacques de Beaulieu was an ignorant Italian peasant, but his contacts with French surgeons and his travels in that country, enabled him to become a highly skilled lithotomist, his method eventually being improved into the later standard lateral operation, and his very name coming down to us in its French guise. In France at this same period was Saviard, who has left a description of a case of congenital absence of the penis, likewise Alexis Littrè, whose description of a special type of hernia, is still commemorated in modern text-books.

Eighteenth Century Lithotomists.—A great name of the eighteenth century is that of Tommaso Alghisi of Pisa, one of the most noted Italian professors and practitioners of surgery of that period, but the supremacy in urology which France was later to attain, was even then foreshadowed by the eminence of a number of lithotomists in that country, chief among whom were Claude Nicholas Le Cat, François Ledran and Jean Baseilhac, better known as "Frère Cosme." In England the most prominent name is that of William Cheselden who died in 1752, though many references to the skill with which English surgeons extracted calculi show that his accomplishments were shared by a goodly number of lesser lights.

Le Cat operated upon the grooved staff, which, after introduction, was inclined to the right and brought as far as possible toward the perineum. While his assistant raised the scrotum, the operator made a long incision through the skin and fascia, beginning at the membranous urethra beneath the pubis and extending obliquely as far as the anus. Digital exploration now determined the exact position of the staff in relation to the pubis, after which the point of the incising instrument was inserted in the membranous urethra and into the groove upon the staff, and by a single stroke carried almost to the prostate. A second knife was then introduced while the assistant held the first knife in position, this being withdrawn when the second one had been passed down to the staff. This was now employed to make an incision from above downward and inward toward the bladder, thus cutting into

the prostate and probably not infrequently also making a small aperture in the bladder. In order to incise the prostate the staff had to be carried further backward and inward so that the gland could be reached. When the parts had been sufficiently dilated, both the second knife and the staff were raised high enough to permit the introduction to the bladder of a conductor which was passed along the groove of the staff.

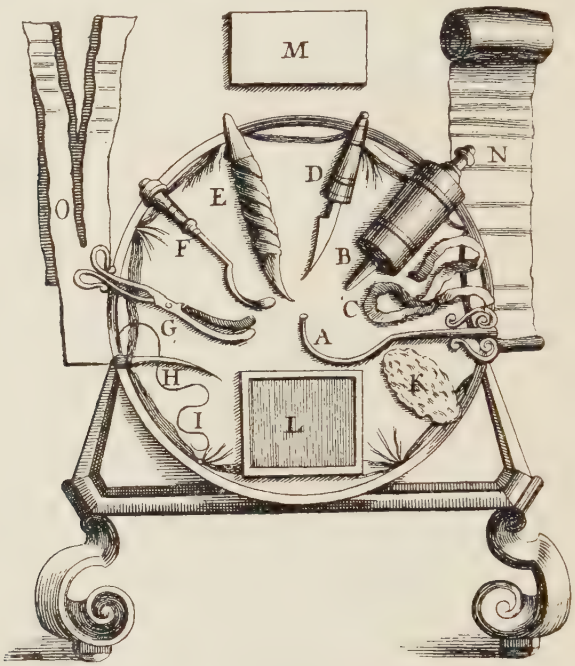

Fig 1.—Instruments used in the extraction of calculi. (From Morand's "Treatise on Lithotomy," 1747.)

Ledran divided the membranous urethra in the same way as that of Le Cat, but he then introduced his finger into the rectum so as to push the staff upward as he at the same time exerted pressure on the pubis, and also caused the handle of the staff to deviate toward the right, thus bringing the groove at its tip to a position opposite the internal sphincter, between the left tuberosity of the ischium and the anus. The aim was only to incise the bulbous urethra. The incision was then continued by introducing a large grooved director, along which another knife was passed, the incision in the urethra being carried forward until the prostate was opened upon the left side, this being possible when the staff was inclined slightly forward.

Ambrogio Bertrandi (1723 1765) who was professor of surgery at Turin during this period and appears to have traveled all over Europe observing surgical practice, criticizes the curve given to the staff by the

French operators, claiming that because this curve was neither full nor long enough they were obliged to begin their incisions too high and could not prolong them to the anus, so that in order to make a proper incision they were forced to incline the staff after it had been introduced. In Bertrandi's opinion, the simpler procedures employed in England were safer, equally efficient, and much more rapid.

Frère Cosme's chief contribution to the lithotomy operation was his instrument, designated as the *lithotome caché* which was actually little more than a modification of another instrument called *bistouri caché*, which had been for a considerable time in use in the operations for hernia. By the employment of this lithotome, Baseilhac or "Frère Cosme" obtained better dilatation of the vesical orifice, but the use of the instrument carried with it a very grave danger of injury to the surrounding structures, such as the rectum, vas deferens or seminal vesicles.

Early Nineteenth Century Urology.—Studies of Renal Disease.—The eighteenth century, except for the work of the lithotomists, shows little advance in urological surgery or in the treatment of diseases of the genito-urinary tract. John Hunter's observations upon venereal disease served rather to retard than to promote an intelligent understanding of these affections, for he confused syphilis with gonorrhea, though he clearly differentiated between hard chancre—which still bears his name in token of this distinction—and chancroid ulcer. with which, up to this time, it had been very generally confused. It is not until we come upon the name of Richard Bright (1789–1858) that we are able to discern any real advance in the handling of urological conditions. It was in 1827 that he published his "original description of essential nephritis, with its epoch-making distinction between cardiac and renal dropsy" which at once established his reputation all over Europe. White clouds in the urine had been noticed even by Hippocrates; Saliceto, the Italian surgeon, had pointed out the association of dropsy, scanty urine and hardened kidneys (*durities in renibus*) in 1476, and the correlation between dropsy and albuminous urine had been established by William Charles Wells (1811) and John Blackall (1813), but Bright was the first to connect these symptoms with the peculiar inflammation of the kidneys which he found in so many postmortems, and his thesis soon made its way everywhere, on account of its immense importance in medical practice.

The discovery of anesthesia gave an unprecedented impetus to every kind of surgery, that upon the genito-urinary tract proving no exception. Following the year 1846 when the first demonstration of anesthesia was made, there was a rapid increase in the number and scope of such operations, and the practical application of the principles of asepsis first set forth by Lister in 1867 made possible the successful performance of procedures hitherto wholly undreamed.

Many years before this, however, French surgeons had given great attention to instruments for use in urological practice. Souberbiele

devoted himself especially to lithotomy, and is said to have performed more than twelve hundred operations by the suprapubic method. At this time too, lithotrity was first introduced, Civiale successfully performing it upon the human subject in 1824. Even before that date, Leroy d'Etoilles had devised a three-pronged instrument for seizing and perforating the stone in the bladder. These operators, however, were subjected to bitter criticism by a third French urologist, Heurteloup, who devoted the greater part of his professional life to study on the subject of lithotripsy, and is said to have spent a hundred and fifty thousand francs in perfecting the inventions and improvements to already-existing instruments, for which his genius was responsible. To Reynaud, the urological profession in France assigns the invention of medio-lateral lithotomy; to Vidal de Cassis that of "quadrilateral;" and to Civiale, the "medio-bilateral," which was warmly approved by Lallemand, and introduced into England by Sir Henry Thompson, who became the foremost urological surgeon in the British Empire.

The supremacy of the French in the field of urology was continued by younger enthusiasts from the colonies, chief among whom was Felix Guyon, who as professor of genito-urinary surgery of the Paris Faculty, has been able to extend his influence all over the medical world. His writings on genito-urinary diseases and surgical affections of the bladder and prostate still remain standard works upon these subjects. His successor, Joaquin Albarran, a Spaniard born in Cuba, equaled, if indeed, he did not excel his master in many phases of their specialty, his studies of renal function and diagnosis by urinalysis having proved invaluable contributions to urological practice, and his work on surgery of the genito-urinary tract still remaining a standard text. Yet another French surgeon, while not devoting himself exclusively to urology, made an epoch-making contribution to this subject. This was August Socin, who in 1875 published a valuable treatise on surgical diseases of the prostate, a subject which had, up to that time, received but little attention.

American Urologists of the Period.—In our country, the names of Henry Jacob Bigelow and Samuel David Gross stand out most prominently as those of surgeons whose contributions did much to elevate the practice of urology to the place it holds in the United States today. The text book on diseases of the genito-urinary tract which Gross wrote in 1861, contains the first account in any language of the distribution of urinary calculus, and as an operator he is distinguished as having performed the first laparotomy for the repair of a ruptured bladder. Bigelow, though he took his degree in his native Boston, studied in Paris under the French masters of urology, so that later, when he became professor of surgery in the Harvard Medical School, the accomplishments of the French school became a part of the special knowledge of the rising generation of American medical men. Bigelow's greatest personal contribution, aside from his influence as a teacher which can never be measured, was his litholapaxy operation, which brought

about a revolution in the treatment of vesical calculus. The instrument which he devised made it possible, as he himself expressed it, "to remove at once a far greater quantity of débris than has hitherto been considered possible;" for "it will be no longer essential to pulverize the stone, but only to comminute it, and if, in so doing, the lithotrite can be kept free from impaction, the process will be more rapid and efficient." Bigelow is probably best known to medical men of every kind on account of his having sponsored the use of anesthesia in surgical operations, and it was largely because of confidence in his high professional standing that the attempts of Morton to commercialize the idea did not prejudice the medical profession against it as unethical.

Prostatectomy.—The progress of urological surgery made possible by the introduction of anesthesia, can be well illustrated by the history of prostatectomy. Hypertrophy of the prostate was not recognized as such until the eighteenth century, when John Hunter and certain other English surgeons made several attempts to tunnel the enlarged prostate with the catheter, when retention of urine had occurred from occlusion of the vesical neck by the enlargement. This procedure however, proved highly dangerous to life, and was abandoned by the British surgeons for this reason, and a similar experience fell to the lot of the French and German urologists, death following Billroth's only attempt to employ this means of accomplishing catheterization. The French operators however, who have been mentioned in citing the work in the early part of the nineteenth century, made use of compression brought about by various means, in order to open a passage to the bladder, and the American surgeon, Phillip Physick, also successfully employed a similar method. But these attempts were so painful that they naturally did not come into use except in cases of the greatest urgency.

Because perineal lithotomy had been known and practiced from ancient times, it naturally followed that the first attempts to remove hypertrophy of the prostate were by perineal operations. Accounts of what may very well have been the removal of such an enlargement are found in literature as early as 1639, and it is definitely recorded that Sir William Ferguson combined perineal prostatectomy with lithotomy before the introduction of anesthesia.

The first operation undertaken upon the prostate alone seems to have been done by George James Guthrie, an English army surgeon, who served with the British forces during the war in 1812, and operated upon the field of Waterloo. Making use of a catheter which carried a concealed blade, Guthrie divided the "bar at the neck of the bladder," which he believed to be a fold of mucosa which enlargement of both prostatic lobes had stretched across the vesical orifice. Mention has already been made of the instruments which the ingenious Civiale produced for the performance of urethral prostatectomy, and Mercier, another French surgeon whose name is especially identified with procedures upon the prostate, also devised and improved other instruments, disputing vigorously after the Gallic fashion with d'Etoilles and

Civiale, over the question of priority. The elbowed (coudé) catheter is properly attributed to Mercier.

After the introduction of anesthesia the Bottini method of cauterization was for a time a popular operation, but this, although modified and used with success both in Europe and this country, did not on the whole prove satisfactory even to those who were in the beginning its most ardent advocates. Tapping the bladder, either through the rectum or above the pubis, when it was found impossible to pass a catheter, had been attempted during the eighteenth century or probably even earlier, but this was, under the old conditions surrounding such procedures, a decidedly dangerous attempt, and the fact that some of the victims of this method developed urinary fistulæ which resisted all attempts to close them, finally suggested drainage of the bladder by a suprapubic opening, a method which was employed with considerable success by Sir Henry Thompson in England.

Reginald Harrison, another English surgeon, combined the opening of a perineal fistula with perineal prostatectomy, a procedure which he first carried out in 1881. Attempts to remove the entire gland were not successful until very recently, and the claims of Freyer, who in 1901 devised the operation which bears his name, to have succeeded in this attempt, have been hotly disputed. Prostatectomy by the perineal route was a natural sequence of perineal prostatotomy, and it was not until 1887 that the suprapubic route was reported to have been successfully employed by McGill, an English surgeon, though many attempts to reach the prostate in this manner had undoubtedly been previously made.

The Present Century.—The first quarter of the twentieth century has not witnessed so great an advance in the choice of means of access as it has in refinements of technic and vast improvements in the instruments employed, in increased accuracy of diagnosis, and consideration of the indications for operation. And this is true, not only for interventions upon the prostate, but for every form of urological procedure, diagnostic, therapeutic and operative. The cystoscope, invented by Max Nitze in 1877, gave us cystoscopy, urethroscopy and rectoscopy, and the perfection of the incandescent lamp so that it could be introduced into diagnostic instruments, has really made possible the unparalleled progress which placed urology, but a few years ago a neglected and almost despised branch of medicine, in the forefront of specialties. The discovery of the roentgen-ray and its application to diagnosis should have a share in this acknowledgment, for the use of injections of opaque media to aid roentgenological observation—pyelography—and still more recently, the injection of gas into the peritoneal cavity for the same purpose—pneumoperitoneum -have only yesterday given an entirely new aspect to our specialty.

Chemistry and Biology.—Hand in hand with these advances in physical diagnosis have gone those made possible by the untiring work of chemists and biologists. Beginning with Fehling's test for sugar as

far back as 1848, we have witnessed a long line of ardent, self-sacrificing workers, whose unflagging energies have made possible the high degree of accuracy with which renal function and other important data—both normal and pathological—can be estimated and observed. Indicanuria was made known by Jaffe in 1877; Ehrlich described his diazo-reaction in 1882; the year 1894 saw the introduction of cryoscopy by Sandor Koranyi; Albarran succeeded in producing experimental polyuria in 1905; and the year 1910 saw both the publication of Ambard's "urea coefficient," and the revolutionary test-method of Rowntree and Geraghty, by which the injection of phenolsulphonephthalein, and the subsequent measurement of the amount excreted in the urine, provides the best known method of estimating the functional capacity of the kidneys.

Radium.—One of the greatest therapeutic aids which has been placed within reach of the urologist during recent years, is radium, the honor of having originated it, both chemically and therapeutically, belonging to France. The existence of radioactivity was demonstrated to the world in 1896 by Henri Becquerel, following the discovery of radium by the Curies, but it was not until a number of years had passed that the employment of this force as a curative agent became practical. In 1906, Henri Dominici, English by birth, but French by inheritance and education, observed that by eliminating secondary radiation through a careful choice of filters, the rays thus selected showed a marked innocuousness for healthy tissues, while at the same time they retained their lethal effect upon neoplastic growths. Dominici's studies quickly made possible the successful radium treatment of deep-seated malignancies, the first satisfactory results being obtained following application to those of the female generative organs. Dominici also discovered the remarkable curative action which radium exercises over gonorrheal rheumatism. He exposed malignant growths of the bladder to radiation through a suprapubic cystotomy, thus being able to bury the radium directly in the substance of the tumor.

Pioneers in the Use of Radium.—The work of Dominici was rapidly extended by various French urologists, among whom may be mentioned Minet, Reynier and Fabre, Pasteau and Degrais, and especially the very eminent genito-urinary specialist—Marion. In our own land the use of radium in malignancies of the genital and urinary tract has become very general, and a list of those who have used and advocated it would read like the membership-list of a national urological society. Especial mention should be made however, of the work of B. S. Barringer, who was among the first to apply it to carcinoma of the bladder and prostate, and whose efforts in this direction at the Memorial Hospital in New York City, have been an epoch-making contribution toward the conquest of the most dreaded of all urological diseases. Much valuable work has also been done by Young, by Keyes, and at the Mayo Clinic by Braasch, Bumpus and several others; by all of whom, our knowledge of the therapeutic possibilities of radium, as

well as the best means of employing it and the dangers which must be avoided while using it, have been immeasurably extended.

Present-day Workers in the Urological Field. No history of urology, however brief, could lay claim to accuracy or completeness unless some mention were made in it of the men who are at present extending the scope and efficiency of urological practice in nearly every state in our Union. It becomes, however, a very difficult task even to name each one who has made, or is even at this moment making, contributions to our specialty which continually increase its prestige and usefulness. Some have already been mentioned, and others will be called up in later pages, while constant reference will have to be made to the things which they have accomplished, else would a study of this kind be quite without value.

REGIONAL ANESTHESIA.

The latest achievement of urological surgery is the employment of regional anesthesia. As yet we are but just commencing to realize the far-extending possibilities which this technic is offering. As the subjects who come to the hands of the urologist are in the great majority of cases, "poor surgical risks" either by reason of advanced age, as in many operations upon the prostate, or because of great systemic disability, as in nephritics, the question of anesthesia is of even more moment to him who works only upon the genito-urinary tract than to the general surgeon. The perfection of the methods by which we shall be enabled to employ sacral and other forms of regional anesthesia will add immeasurably to the possibilities of finding operable conditions where now the surgeon sees patients quite beyond his power to aid. Indeed, the possibilities which are thus being opened before the urologist seem well-nigh without limit.

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PART II.

DIAGNOSTIC PROCEDURES IN UROLOGY.

CHAPTER III.

HISTORY-TAKING AND PHYSICAL EXAMINATION.

When a patient displaying urinary symptoms or other phenomena referable to the genito-urinary tract presents himself for advice it is evident that the physician's first procedure must be to make an examination. It is absolutely essential to do this, no matter what symptoms the patient presents, whether they be urological, cardiac, respiratory, gastric or mental. Every physician should keep in practice by constantly reviewing what he learned when he studied physical diagnosis in the classroom. The medical man who makes a careful general examination of his patient is certainly in a better position to diagnose and treat any case than is he who accepts the patient's diagnosis and sometimes, even his suggestions for treatment. Such a careful general examination having been made the examiner can then direct his attention to the urinary tract.

HISTORY-TAKING.

History-taking is the first step in examination, for it is only by a thorough consideration of the history that one can arrive at an accurate diagnosis. It is well at first to let the patient relate his story in his own words, interrupting only so much as is essential to bring out more clearly such points as seem likely to have an important bearing upon the condition. When the tale is finished the history may be recapitulated and all information obtained from the patient or his friends jotted down in a systematic way so as to constitute a useful record for future reference.

This record should include:

A. 1. The nature of the complaint.
   2. The family history.
   3. The personal present and past history.

B. 1. The patient's statement regarding his condition.
   2. General physical examination.
   3. Special examination of the genito-urinary tract.

A. **The Nature of the Complaint.** 1. **The Complaint of the Patient in his Own Words** should always be the first item of the history and should invariably be recorded exactly as he states it. Moreover the information should be elicited by questions which are not leading, *i. e.*, if the physician asks, "Why have you come to the hospital?" and the patient replies "For a pain in my back," this item should be placed at the head of the history, and not "The patient complains of a pain in the lumbar region." After this should be set down all the essential items relating to the trouble for which the advice of the examiner has been sought. Often it is a good plan to inquire the exact date at which he last felt perfectly well, for though this is seldom forthcoming in precise figures, it will serve to set a limit to the patient's recollections, and help in determining the etiology and duration of the complaint. Any variation in weight is of importance, so the normal weight and any deviations from it should be a subject of inquiry.

As *pain* is in most cases the immediate reason for seeking medical assistance, it is usually easy to obtain a somewhat detailed history of its manifestations in a given case. It is essential to jot down the statements made in regard to its location, the direction in which it radiates, character ("throbbing," "grinding," "knife-like" and so on), intensity and duration. Special types of pain are characteristic of different diseases, and particular organs; for example, the pain of tenesmus or strangury, felt in the bladder at the end of micturition, is due to inflammation of the bladder neck; chordee or painful penile erection may usually be related to inflammation of the corpus spongiosum, and a "dragging pain" in the groin will at once point to an inflamed cord, or the undue weight of a swollen testicle.

Pain in the kidney or ureteral regions has especial diagnostic value, and the examiner should take care to find out whether the painful sensations are referred to the back, to one side, underneath the free border of the ribs, or in the ilio-costal space in front. Pain in the ureter is frequently reflected, either toward the bladder and testicles below, or the kidney above. If a calculus is present, or a kidney is misplaced so as to twist its pedicle—the condition designated as Dietl's crisis—the pain will have a definite point of maximum intensity. The pain caused by abnormal states of the kidneys and ureters is likely to occur in zones. In the kidney region the zone will be triangular, the base posteriorly between the inferior margin of the ribs, the spinal column and the pelvis, and the apex of the triangle anteriorly below the free margin of the ribs. The patient complaining of kidney pain usually locates it in some part of the area included in this triangle, and bimanual palpation will elicit a corresponding region of tenderness.[5]

Pain in the groin may have important diagnostic significance, even to apparently unrelated conditions. For example, in epididymitis, extension of the inflammation from the urethra along the vas deferens will cause pain in the groin, before attention is called to the epididymitis itself. Inflammation of the seminal vesicles will cause a "dull ache"

in the groin, and it may also be the result of pressure on the ejaculatory ducts, or hypertrophy of the prostate, or prostatitis.

A sense of fullness, or indefinite pain in the suprapubic region, is most likely to be due to retention of urine, though if this is sudden and acute, the patient will complain of "cramps." Inflammation of the bladder may produce it, especially if the cystitis is the result of a tubercular process, or the presence of a calculus.

The character of the urination is, of course, a matter of the greatest moment, *frequency* and *difficulty in voiding* being the complaints most often heard. The details of this diagnostic point will be considered a little further on.

2. **Family History.**—Family history should next be taken up, and inquiry made concerning all the immediate relations, their ages and state of health if living, and if not, then ages at death and causes of death. Concerning each relative note the occurrence of any abnormality or deformity, especially if it has shown a hereditary tendency; *e. g.*, undescended testicles, hypospadias, etc. Make a special note of any infectious diseases which have occurred among other members of the patient's family; *e. g.*, tuberculosis, kidney disease, or cancer. Any history of nervous or mental affections is especially important.

Though the tendency of modern medicine is on the one hand away from the conception of disease which "runs in families," on the other hand advance in the science of genetics has led us to regard the family history as of very great importance.

Though we now know that syphilis and tuberculosis cannot be inherited, and what was formerly supposed to be transmitted to the offspring in the germ plasm of the parent is really an infection conveyed in practically the same manner as the contagions of adult life; yet the "uric acid diathesis" of which so much was heard a half century ago is still recognized today as traceable to hereditary influences; for the tendency to the accumulation of crystalline masses and the formation of concretions, undoubtedly appears in successive generations of the same family.

It is also quite generally accepted that many conditions which are of special interest to the urologist—arteriosclerosis, diabetes and nephritis—together with those pathological disturbances of the nervous system which are closely related to diseases of the genito-urinary tract—certain lesions of the brain and spinal cord, or special manifestations of hysteria and neurasthenia—are strongly influenced by hereditary tendencies. Derangements of the nervous system appear particularly significant when we bring to mind the close relationship which exists between the mechanism of the nervous system and that of the urinary tract. Lesions of the nervous system may occasion diseased functional conditions of the kidney, the bladder, the prostate, the urethra, or any one of the generative organs. It is well established that nerve derangements may be the direct cause of organic changes in the kidney.

The fact that members of the family of the individual under examina-

tion have shown a tendency toward early sclerosis of the arteries may be extremely valuable in pointing to a diagnosis. Degeneration of the arteries, resulting in apoplexy and different manifestations of paralysis, appears to be increasingly common in the United States, and seems to bear a direct relation to a rise in the general standard of living and the nervous strain of competitive modern vocational life. Easy living conditions tend to induce arteriosclerosis, and excessive nerve strain reacts upon the kidneys, often producing such diseases as interstitial nephritis.

Moreover the family history is of great importance on account of the likelihood of contagion induced by the close associations of a single household. If tuberculosis has attacked any near relative, it will at once place the examiner upon his guard when he detects evidence of a chronic process in the urinary tract for which there seems to be no immediate explanation, and even if the physical examination of the lungs has been wholly negative, this bit of family history may enable him to determine the presence of a tuberculous vesiculitis, or other tuberculous infection of the genito-urinary apparatus. Guiteras noted that many of his prostatic hypertrophy patients told him that their fathers had suffered from the same symptoms, and Sir Henry Thompson made a similar observation in regard to strictures.

Hereditary and familial tendency to malignancy is still a much-mooted question; but no examiner will lose anything by giving careful consideration to the possibility of a tumor or cancer in a patient who complains of symptoms referable to prostate, bladder, or kidney, and supplies a history of malignancy of any kind which has occurred in his immediate family.

3. **Personal History.**—In the case of young children the personal history may sometimes be carried back to the intra-uterine period, but in most instances the examiner can expect to glean only such information as is stored up in his patient's memory.

The age of the patient is naturally of very great importance. Each period of life has its peculiar disturbances of the urinary and sexual apparatus. In infants and young children disease referable to this portion of the body is relatively rare; vesical calculus causing frequent micturition with accompanying pain and tenesmus is occasionally seen, and a tight prepuce or congenital stricture may produce serious disturbance of the urinary function. In older children we must be on the lookout for lesions due to infection with the gonococcus, especially in little girls, whom the delicacy of the vaginal mucosa makes peculiarly liable to inflammatory activity by this bacillus. Tuberculosis of the genito-urinary tract is also not infrequent among children.

At puberty and following the adolescent period, the incidence of tuberculosis greatly increases. Active gonococcal infection is not seen so frequently, but the results of such infections, in men, diseases of the vesicles and prostate, in women, of the tubes and ovaries, with stricture and cystitis, are often in evidence. As Pillet tersely remarks, "a

primary blennorrhagia at eighteen, means a stricture at twenty-five." As age advances, the chances of seeing tuberculosis decrease, but malignancy is likely to occur, while the kidney and bladder disturbances noted in early manhood are still often seen. Lesions of the nervous system, especially those due to syphilis, contribute largely to swell the number of the middle-aged genito-urinary patients, and stricture of the urethra also occurs frequently.

In old age malignancy and the formation of calculi become increasingly common, and various diseases of the prostate claim a large share of the urologist's attention.

Given identical symptoms in a patient aged twenty, or one aged sixty years, we can usually be assured that there will be a widely divergent causal factor in these two individuals.

The *diseases of childhood* should all be listed and their possible part in the etiology of the present complaint carefully weighed. Scarlet fever and diphtheria frequently induce nephritis, and less often, kidney inflammation may result from variola, varicella, measles, meningitis, typhoid fever or influenza. Any severe disease, such as pneumonia or acute enteritis, may irritate the kidney to the point of inflammation in striving to eliminate noxious products. The kidney lesions may be started by the toxins generated by infectious bacteria, or may be caused by the direct action of the organisms themselves.[4] Chronic nephritis is a frequent sequel to such acute infection, and is seen especially after scarlet fever.

Orchitis is a not infrequent complication of mumps in boys, and has also been reported as an accompaniment of typhoid fever, tonsillitis, influenza, smallpox and arthritis. The orchitis of mumps is most frequent near the time of puberty, being almost unknown in childhood, and being observed in at least 5 per cent of the cases of mumps in young adults. In 432 cases of mumps among soldiers, Laveran met with orchitis 156 times, and 73 patients later had atrophy of the testicle. It is extremely difficult in many cases presenting kidney stones to find the original cause of the stone formation, but it is our impression that these concretions never form unless there is a pathological groundwork underlying, in the form of necrotic or damaged kidney tissue upon which salts are deposited, and that in very many cases the infectious diseases of childhood are responsible for this pathological groundwork.

The importance of eliciting a history of all other infections seems hardly necessary to emphasize. In urology, more perhaps than any other specialized branch of medical practice, the lesions often have origins remote both in time and bodily location. Our increasing knowledge of focal infection is constantly opening up new etiological avenues; the mention of "rheumatism" now quickly brings to mind a possible gonococcic infection, and the causal factor of many kidney and bladder affections has been finally traced to the site of persistent attacks of tonsillitis. The "pneumonia" which left a troublesome cough may

point the way to a diagnosis of tuberculous infection, even before one has gone over the chest.

Of the importance of a history of antecendent venereal disease there should be no need to speak, yet not infrequently the remote effects of these infections, especially gonorrhea, are left out of account. Many a sterile woman has been subjected to repeated gynecological exploration and operation in a vain endeavor to satisfy a desire for offspring, when all the while the sterility was due to an acute bilateral epididymitis resulting from a forgotten attack of gonorrhea suffered long before by her "perfectly healthy" husband. In the same way a negative Wassermann does not always insure either patient or physician from having to deal with the remote sequelæ of syphilis. He who has been given a history of venereal disease must keep it constantly in mind throughout the examination, and weigh it carefully against every other factor which is arrayed for the establishment of a diagnosis.

A history of persistent headache should always arouse the interest of the examiner. There has been reported the case of a bibulous house-painter whose "sick headaches" were variously attributed to alcoholism and lead poisoning. Blood was present in the stool and pus in the urine, and autopsy disclosed stones in the kidney with abscess and nephritis.[3] The headache of nephritis, excepting the sudden attack due to uremia, is in most cases caused by the arteriosclerosis which so often forms an essential part of the chronic nephritides. The pain is apt to be of a throbbing character, somewhat shifting, often accompanied by vertigo and tinnitus. Butler says that in such cases, he has more than once been struck by the presence of a vague fear on the part of the patient as to the final result—forebodings which have in two cases been unconsciously realized by the supervention of an apoplectic attack.[2] While frontal headache is most frequently due to a pathological condition of the sinuses, it is not at all uncommon for it to prove to be a manifestation of some renal lesion, or of a chronic focus of infection having its origin in the prostate or seminal vesicles.

Urination.—Very minute inquiry should be made into the urinary history of every patient who presents himself to the urologist. It is extremely important to learn if there has ever been any change in the urinary habits. He should therefore be asked regarding pollakiuria (abnormal frequency); polyuria (excessive secretion of urine, more than 3000 cc. a day); dysuria (difficult or painful urination); urgency (inability to retain the urine after the call for evacuation of the bladder); nycturia (necessity of arising at night to urinate); and oliguria (slight secretion of urine).

Inquiry should also be made regarding alteration in the urinary stream, which is usually indicative of some obstruction at the bladder outlet, or in the canal, and especially whether hematuria has been observed at any time.

In married patients, the *marital history* is often very suggestive, so it is essential to ascertain the number of years married, the state of

health of wife or husband, whether or not there are children, as well as data relating to the number and physical condition of offspring. A history of miscarriages is significant in all cases whether the man or the woman be under examination.

In order to deal with any patient successfully it is necessary for the physician to gain his confidence, and if possible win for himself a genuine respect and regard. The family relations and the home atmosphere often have a strong bearing upon the occurrence of genito-urinary affections. A "nagging" helpmate may be the real cause of a sexual neurasthenia, or even of the mental state which has aided in setting up a nephritis, and many a thrifty housekeeper has swept and dusted her husband and sons out-of-doors, thus exposing them to contaminations infinitely more evil than those she sought to remove. The examiner who can make the patient look upon him as a friend to whom he feels free to reveal his private woes and discouragements may elicit much valuable information in this way. The higher up in the social and intellectual scale is the patient, the greater will be his reticence and the more difficult it will be for the physician to establish confidential relations with him, but a little patience and tact will usually serve to break down the barriers.

Occupation and the environment of the worker, also, have an important bearing on urological conditions. Often a change of occupation will account for physical conditions which are otherwise altogether inexplicable. Even an altered financial status may react upon the genito-urinary system. It is well known to life-insurance examiners that a man who has suddenly risen from comparative poverty to affluence, and thereupon applies for a policy, is by no means so good a risk as a man of the same age and physical state whose outward circumstances have not undergone so sudden an alteration. The moral hazard is far more, and many physical ills which never attended a man when he walked to his daily job, may overwhelm him when he becomes able to motor to business with a hired chauffeur.

The patient's *habits* also have a strong bearing upon any existing pathological condition, and should be the subject of careful inquiry. It is not enough to ascertain his attitude toward the use of alcohol and tobacco, these are important, but the materials which go to make up his three-meals-a-day are even more so. If he is endeavoring to get along with less sleep than he requires, the elicitation of this fact may make clear an otherwise perplexing lack of general resistance. Again, a man who spends his leisure in pool-rooms and movie houses, where ventilation is poor and space at a premium, may present a systemic state which is comparable to that of the man whose home and vocational surroundings are greatly inferior.

Inquiry should be made concerning the hours of work and of recreation, the amount and kind of food taken, and the usual state of the appetite; the use of alcohol, tobacco and other drugs; how long a time the patient allots to sleep, and how much water he drinks. The answers

to these questions form an important part of the case record, and the personal history thus becomes a matter of the very greatest moment in urology quite as much as in the general practice of medicine.

B. **Present Condition.**—1. **Patient's Statement.**—Having informed himself concerning the patient's general health and specific urological condition, the examiner should now take up his chief complaint and make particular inquiry into: (1) The probable cause of patient's trouble; (2) its duration; (3) the course up to the present time; (4) minute details of the present symptoms. If time is limited one may save much by restricting the patient entirely to answering the questions which are asked him, following which it is customary to invite him to add to the facts obtained, if at the end of the examination he thinks anything of importance has been omitted.

2. **General Physical Examination.**—When the history has been completed a general physical inspection should be made. The alert physician will have already noticed the general attitude. It is important to observe whether the patient appears nervous, worried, or morose, or in any way uncomfortable, either physically or mentally. In some instances the condition and color of the patient's skin may at once point to a definite diagnosis. If, for example, he has a yellow skin and a cachetic-looking body with a prostate suspiciously hard but not unquestionably malignant, the general appearance will add much weight to the suspicion of a probably existing malignancy.

The *general examination* should include inspection of the head, eyes, ears, mouth, tongue, gums, teeth, nose, pharynx, larynx and neck; a thorough examination of the heart and lungs; palpation of the abdomen; tests of all reflexes; determination of the blood-pressure, and a complete urinalysis. Ascertaining the condition of the circulation, the lungs, and the digestive tract is especially important. No examination should be considered complete without internal palpation of the rectum.

3. **Examination of the Genito-urinary Tract.**—Examination of the genito-urinary tract should include inspection and palpation of the penis, the testicles and the epididymes, with palpation of the kidneys, the suprapubic region and the prostate, and an inspection of the urine.

External examination should begin with inspection of the external organs followed by palpation of the kidneys and ureters, and palpation and percussion of the bladder. This in turn should be followed by rectal palpation of the prostate, seminal vesicles and other internal generative organs which can be reached by this route and external palpation of the penis, urethra and scrotal contents. *Inspection* will often give an immediate clue by revealing an enlargement, not alone of the external genitals, but often also of some internal structure, which has increased in size to such an extent as to be visible upon the surface. For example, periurethral swelling and follicular abscess will often cause sufficient swelling along the course of the urethra to be observable with the unaided eye. Externally visible edema, due to inflammation and extravasation of urine is not uncommon in the same location.

In cases of over-distention of the bladder, this viscus may appear as a tumor extending upward as far as the umbilical region.

Inspection of the renal region is not so likely to be of diagnostic value, unless there is a very marked enlargement of these organs, but Chetwood suggests that in acute inflammatory affections of the kidney, even when there is no enlargement sufficient to attract the examiner's eye, the difference in the mobility of one side as compared with the other, is plainly visible.

Inspection of External Genitals.—The size and shape of the organs will naturally be the first matter to engage the examiner's attention and even a cursory inspection will reveal the existence of such marked malformations and anomalies as hypospadias or pseudo-hermaphroditism. More careful search will be necessary to determine the condition of the prepuce, the existence of phimosis, or partial atresia, and the presence or absence of lesions, such as ulcers, abscesses, nodules or enlarged glands. The meatus should be thoroughly examined, and its size, shape and general condition noted. Congenital strictures, either at the meatus, or near the outer end of the fossa navicularis, are very frequently encountered in urological practice, and as they give rise to no symptoms in the great majority of cases, are likely to be overlooked in the customary physical examination.

If the meatus shows induration, with the lips pressed together, the examiner will at once suspect a syphilitic infection, even if he has failed, as is often the case, to elicit any history of venereal disease. In like manner, ulceration at the meatus, will suggest chancroid. If a discharge is present it probably has diagnostic significance, and a smear should be obtained for microscopic study.

Palpation is a valuable means of detecting the presence of disease in kidneys, prostate, testicles, and epididymes, while *percussion* is useful in supplying information concerning the possible location of an abdominal tumor. Casper is responsible for the statement that differentiation between tympany and dulness may help us to decide whether we have to do with a tumor of the kidney or with another kind of new growth, but others claim to have been able to gain little information from percussion, and that the belief so general among physical examiners that a kidney tumor will fall backward when the patient is lying on his back, with pelvis and legs lifted, is also erroneous.

The combination of palpation with percussion may, however, frequently give information as to the presence or absence of tumors of the kidney, or the neighboring organs. Palpation of the kidney should be undertaken with the patient in the dorsal position, with the knees flexed, and the abdominal muscles thoroughly relaxed. One of the examiner's hands inserted beneath the back presses upward between the twelfth rib and the crest of the ilium, while the other hand presses downward, from directly above, upon the abdominal parietes. Keyes suggests that the kidney is sometimes more palpable if the patient be turned upon the side opposite to that which is being examined, lying

with the knees well drawn up, and that palpation of the abdomen with the patient erect but bending slightly forward may reveal renal mobility that otherwise would escape observation. We have not found these methods more useful than the ordinary positions.

In general, palpation of the kidneys should be bimanual, and is a useful method for the detection of renal enlargements which are due to hydro- or pyonephrosis, concretions, or the presence of new growths, malignant or benign. Light palpation in this region will often enable the examiner to detect muscular contractions or spasm of the muscles induced by some acute affection. Muscular rigidity of the entire affected side is not infrequently revealed by palpation, and the region of the quadratus lumborum muscle is of importance, as muscular rigidity may be present as one of the signs of lesions in the kidney which are not detected by more general palpation.[33] Acute inflammation of the kidney produces lumbar tenderness, sometimes over the entire lumbar area, but more frequently only in the costo-vertebral space and the region of the tenth, eleventh and twelfth ribs.

When the kidney is enlarged, it usually forms a movable tumor of ovoid form, partially hidden from both inspection and palpation by the over-arching ribs. If tenderness is elicited it is a very likely indication of inflammation, and the diffusion of a perirenal exudate is so characteristic as to be immediately apparent to an experienced examiner. It is impossible however, by palpation alone, to distinguish an enlarged kidney from an adrenal or retroperitoneal neoplasm, so this method of examination really reveals little more than the probability of a mass in the loin being of renal origin. If the kidney is very greatly enlarged it is often extremely difficult to tell whether the tumor may not arise in the pancreas, gall-bladder, or even the liver. The examiner who keeps his anatomy well in mind, however, will recall that the kidney lies further to the side than any of the organs just mentioned, with the exception of the right border of the liver, and can therefore ordinarily be distinguished by lumbo-abdominal palpation.

Lumbo-abdominal palpation is performed as follows: The examiner sits at the right side of the table, the patient lying close to the edge. Making use of his left hand the examiner presses upon the costo-lumbar angle (formed by the junction of the twelfth rib with the external edge of the sacro-lumbar mass), at the same time placing the right hand upon the antero-lateral abdominal wall, somewhat external to the *linea semilunaris*, the hand being directed upward so as to come under the thoracic wall (just below the free border of the ribs). The patient is then directed to breathe deeply, while the right hand is pressed firmly downward, as the wall relaxes between inspirations.[17]

Sometimes this technic will fail to make the kidney palpable, but if the left hand taps the lumbar wall sharply, *renal ballottement*[33] may be elicited. This is a sensation which bears a certain resemblance to fetal ballottement, and is imparted to the palpating right hand when the tap of the left fingers from behind causes a mass within the cavity

of the abdomen to come in contact with them. Glénard recommends that ballottement be first attempted during normal respiration; the patient is then told to breathe deeply, and the maneuver is repeated as inspiration ends, and the abdominal parietes relaxes.

Ballottement will reveal slight enlargements or mobility, but is useful only in conjunction with other means of diagnosis for, as pointed out by Keyes, one may obtain ballottement from a mass of tubercular glands and from a neoplasm or "corset lobe" of the liver.

If the kidney is found to be freely movable or markedly enlarged, it can be best examined by ordinary bimanual palpation. With one hand on the back and the other upon the abdomen, the organ can be easily outlined and its size and shape, as well as its range of motion, determined by palpation and percussion.

Palpation through the abdominal wall will not locate a normal ureter, but if inflammation exists it will produce points of tenderness along its course. Inasmuch as tenderness may be due to other causes, however, it may lead to a wrong diagnosis, and more than once an inflamed right ureter has been designated as appendicitis or cholecystitis. The pelvic ureter may be palpated in the female at a point where it runs transversely across the anterior vaginal cul-de-sac; at other points it is impalpable, except when greatly enlarged.

In the male, rectal palpation on the anterior wall will sometimes give some information concerning the condition of the ureter. If a stone has lodged at the ureteral entrance to the bladder, beyond the seminal vesicles, it may be palpated through the rectal wall.

Bladder.—A certain amount of information concerning the bladder may be gained by palpation and percussion. In cases of prostatic hypertrophy the walls of the bladder may be greatly thickened, and retention may cause such marked distention of this viscus as to lead to a diagnosis of abdominal tumor. The examiner will only be able to palpate the bladder when it is distended at least half way to the umbilicus. If the distended bladder is percussed above the pubis it will give rise to a dull note, and the extent of the area of dulness will be in proportion to the distention of the bladder.

Rectal Palpation.—Palpation through the rectum may be made by the introduction of the finger only, or in combination with external pressure from the opposite hand. The examining finger should be protected by a well-lubricated finger cot, and it is well to take the added precaution of shielding the hand with a gauze bandage. The best position for the patient is bending over a table, if possible equipped with a heavy pad or sandbag, his feet placed "pigeon-toed" with the heels apart and the knees somewhat flexed, most of the weight of the body being borne upon the lower abdomen and pelvis. The muscles should, of course, be as much relaxed as possible. As the finger advances into the rectum the prostate can be felt on the anterior wall about 2 inches (5 cm.) beyond the sphincter ani. The normal prostate will be palpable as two ovoid lobes, jutting out very slightly, of a firm

and elastic consistency, sharply differentiated from the surrounding tissues. In front of the prostate lies the membranous urethra, usually about ¾-inch (2 cm.) in length and in front of this, the expansion of the corpus spongiosum or urethral bulb can usually be detected. Normally Cowper's glands, which lie on either side of the membranous urethra, are not detectable, but if thickened or hypertrophied from any cause, they may be palpated.

If the perineum is deep, or if there is an existing hypertrophy of the prostate, the finger often cannot be inserted far enough up the rectum to reach the location of the seminal vesicles. When the vesicles are normal they cannot be felt at all, but if dilated or inflamed, they are easily recognized, and their contents can be expressed by means of massage, if it is desired for examination. Enlarged seminal vesicles usually feel like cords running off at an angle from the base of the prostate, so that with it they form a triangle, of which the lower edge of the bladder is the base and the prostate the apex. It is only when greatly enlarged that the vesicles meet in the middle line; when normal there is usually space enough to insert a finger between them. It is well to remember that a vesicle may be considerably inflamed before it will feel abnormal to rectal palpation.

When the patient under examination is thin, Greene suggests that in addition to prostatic palpation by the rectal route, it is well to turn him on his back, introduce the forefinger of one hand into the rectum, and with the other hand on the abdomen, press down over the suprapubic region. Considerable experience is necessary to correctly diagnose diseased conditions of the prostate or seminal vesicles by means of rectal examination alone with no instrument in the bladder, and mistakes in diagnoses thus made are not infrequent, one of the most common being that of concluding that hypertrophy of the prostate or vesicles is present, when in reality they are not abnormally enlarged.

Counter-pressure on the abdomen, in conjunction with rectal palpation may sometimes be helpful in demonstrating the presence of vesical neoplasms, or large concretions lodged in the posterior urethra may be felt through the space between the seminal vesicles.

Palpation of the penis, urethra and testicle adds but little to the information gained by inspection. Irregularities, indurations, and areas of tenderness, should be carefully noted, and any obscure circumscribed fibrosis in the corpora cavernosa should be identified.

In palpating the urethra it is desirable to insert a sound of a size just large enough to fill the lumen of the canal without distending it. A careful search should then be made for infiltration upon the wall of the urethra. Externally we can palpate only the anterior urethra; examination of the membranous portion must be carried on through the rectum, and it is seldom possible to palpate the prostatic urethra by any route.

Palpation of the testicle and vas deferens requires much practice and discrimination on the part of the examiner before he is able to gain

much diagnostic aid therefrom. Any change in the size or sensation of the vas can be recognized by following it up with the finger from the epididymis where it begins, as far as the inguinal canal. The chief points of interest about the testicle are its size and tension as compared with the opposite side, the state of the epididymis, and the possible existence of any pathological conditions hydrocele in particular.

URINALYSIS.

Collection of Urine. In making routine chemical and physical examinations it is usually sufficient to use a specimen of freshly voided urine, which may be deposited in a glass or graduate of sufficient capacity. It is then easy for the examiner to inspect it in order to determine the presence or absence of blood, phosphates or pus, and a portion of the specimen may also be centrifuged in order to secure sediment for microscopic examination.

Possible Errors in Use of Single Specimen.—The value of a single freshly voided specimen is however, rather doubtful. As the composition of normal urine constantly varies from one hour to another, it can readily be appreciated that when disease is present such variations will be even more marked. Though the urine of a diabetic, for example, is commonly loaded with glucose, yet at certain periods of the day absolutely no glucose will be passed; on the other hand it is perfectly possible that an individual in perfect health may pass glucose at certain times. A healthy person may void urine several times without passing any urea. This shows that a specimen taken at random cannot be relied upon as a basis for final diagnosis, for conclusions drawn from such an investigation might be most dangerously misleading. The acidity of the urine often varies greatly at different periods of the same day, and it may be quite impossible to establish a proper relation between symptoms and microscopic elements, such as crystals, casts or cells. The convulsions induced by the growth of a cerebral tumor may be immediately followed by a shower of casts in the urine, yet when a longer interval had elapsed after the convulsive seizure no casts at all would be present. But if urinalysis were undertaken just after the convulsion and diagnosis made upon that single examination it might logically be a diagnosis of nephritis.[25]

Collection of Twenty-four-hour Specimen.—The patient should be instructed to empty the bladder at noon and to reject this voiding. Thereafter he should save all the urine voided up to and including that passed the noon of the following day. No special diet need be indicated, rather he should eat and drink that to which he is accustomed. In case the examiner regards either the vegetable or meat intake as being excessive, he should make a note of this, as well as of any medicines the patient may be taking. The total quantity of urine voided in the designated period should be measured exactly and a record kept of this figure. Then the entire specimen should be mixed gently so that the

sediment may be evenly distributed. If there is but little sediment, it may be well to pour off some of the supernatant fluid before mixing. Several fluid ounces of this mixture are to be used for the examinations.

To preserve the specimen, keep in a cold place when possible. Chetwood suggests that while "there is no ideal chemical preservative, chloroform or thymol are preferable to others . . . a few drops to each 4 ounces of urine." Kelly and Burnham advise adding a few crystals of chloral hydrate to the containing bottle which should then be carefully corked. They also consider chloroform a good preservative. Williams recommends that "a lump of thymol" be dropped into the clean urinal as soon as the collection is begun; gum camphor is not so good, but will serve in an emergency.

Specimens from Female Patients.—To obtain an uncontaminated specimen of urine for bacteriological investigation from an adult female, it is wiser to use a catheter, thus avoiding possible admixture of vaginal secretions.

There was recently published a procedure for collection of urine from female patients which is of advantage in a large office practice.[29] At the office the method is demonstrated to the patient, and she is also given typewritten directions and bichloride for making an antiseptic solution. The patient, or nurse, prepares cotton sponges which are soaked in the solution and the vaginal orifice cleansed. "With the index and middle fingers of the left hand, open the lips of the vagina well, keeping them apart and cleanse the mouth of the urinary tract (meatus) by rubbing slowly from above downward with sponges. Never rub the sponge a second time over the meatus; throw the sponge away; and while keeping labia (lips of vagina) well open, repeat the same movement with a second sponge. Then squeeze out a third sponge, and rubbing over the meatus, insert into the vagina . . ., so that no vaginal discharge can escape."

A bottle is then placed directly over the meatus, into which the urine is passed. Urine is voided into separate bottles the last thing at night, and immediately on rising in the morning, or if the urine is passed during the night the morning bottle is partly filled, and the morning urine added later. The patient is instructed to present herself four hours after the morning voiding, having passed no urine in the interval, a third specimen then being obtained at the office.

This method permits the application of the two-glass test to the female, and should such an emergency arise, allows the collection of an uncontaminated specimen during menstruation. In males the posterior urethra should be flushed with sterile water before the urine is passed into a sterile container. It is desirable to make the bacteriological examination from a fresh, centrifuged specimen, as the old-fashioned method of letting it stand in a conical glass for eighteen to twenty-four hours permitted many bacteriological changes to take place. The same objection, of course, applies to the twenty-four-hour specimen.

Collection of Urine in Infants.—Such great difficulty is experienced in obtaining specimens of the urine of infants that urinalysis of these very young patients is often neglected. At the Children's Memorial Hospital in Chicago, a special urinal of strong glass is used. This is so shaped that it can be held in place by the napkin, the opening covering the vulva or admitting the penis, while excluding the feces.[26]

The use of a common rubber bulb ear syringe for collecting the urine of female infants is used in the Cleveland City Hospital's pediatric service.[10] The top of the bulb is cut away with scissors, the excision being carried down one side and a point left which is large enough to fit snugly into the fossa navicularis. The more slant there is to the cut in the bulb, the lower will be the position of the tip of the collector. A test tube is fastened to the tip of the syringe by means of adhesive tape, or by using the finger of a rubber glove or finger cot slipped over the test tube. Two holes are made in the end of this; one for the end of the collector and one for the escape of air. The apparatus is applied to the vulva by means of adhesive tape, or in institutions by a special binder.

At the Babies' Hospital connected with the Rockefeller Institute the rubber and glass contrivance designed by Finkelstein[10] is used for male infants, but this is not so well adapted for girls. The custom of holding the container in place by adhesive straps is objectionable, because the infant's delicate skin is likely to be damaged, but this may serve in an emergency. Placing the child on a bed-pan is sometimes successful, but one may have to make several attempts before a specimen uncontaminated by feces can be secured.

Catheterization of the urinary bladder is possible in the infant, according to Feer,[9] but requires some practice. In boys it is done with a metal or elastic catheter, the caliber of which should correspond with that of the urinary meatus, and in girls it is easier to use a metal catheter about the thickness of a knitting needle. This eminent pediatrist prefers however, to collect the urine of boys by fastening a strong test-tube over the penis by means of adhesive plaster, and for girls employs a small Erlenmeyer flask, which is placed over the labia after they have been separated and carefully cleansed.

THE GLASS TESTS.

The use of one of the various "glass tests" is frequently a reliable aid in deciding from what part of the urinary tract certain suspicious constituents of the urine are being derived. That most commonly used is the two-glass test of Thompson Walker, the eminent English urologist.[31]

Two-glass Test.—In any test of this character it is essential that the patient should retain his bladder content for at least four hours before the examination is to take place. The urine is to be voided into two

containers, the portion occupying the first container being the washings from the whole extent of the urethra, and that in the second any secretions which may have entered the urine from the organs proximal to the external sphincter—the posterior urethra, prostate or bladder. If the first glass appears cloudy while the content of the second glass is clear, we can safely conclude that we are dealing with an anterior urethritis, though it must be remembered that it is possible for a posterior urethritis to exist with comparatively little discharge, so that no pus makes its way back into the bladder, and the condition thus escapes detection. If antero-posterior urethritis exists, both glasses will be cloudy, but it may sometimes happen that the urine contained in the first glass did not completely wash out the anterior canal and some clouding of the second glassful will take place even when the disturbance is located in the lower section.

Three-glass Test.—Of more value than the method just described is the three-glass test, which is usually conducted as follows:

The patient is directed to pass his urine in a continuous stream into three receptacles which are provided for the purpose; beginning with *Glass No.* 1, then substituting *Glass No.* 2 and finishing the act in *Glass No.* 3. Into *Glass No.* 1 will be voided the bladder urine containing the washings of the entire urethra; in *Glass No.* 2 will be found uncontaminated bladder urine, and in *Glass No.* 3 there will be bladder urine also, but modified by the "strippings" from the prostate and urethra pressed out during the last contractions of micturition.

A modification of this test has been devised which, though slightly more trouble to perform, offers a greater degree of accuracy:[19]

The anterior urethra is carefully washed out until the washings come out clear—*Glass No.* 1 thus showing the condition of the anterior urethra. A soft sterile catheter of small caliber is next passed into the bladder through which the bladder content is drawn off into *Glass No.* 2; this shows the bladder urine with the addition of any drippings from the posterior urethra, or any possible urethral detritus carried in by the catheter. The catheter is kept in place while the bladder is thoroughly washed out, persisting until the washings come clear, which shows that the bladder is empty of all pus or shreds. About 8 ounces of clear fluid is now injected into the bladder and the catheter withdrawn. This completes a thorough washing-out of the anterior urethra and the bladder. The patient now passes 2 ounces of the bladder content into *Glass No.* 3; this shows the condition of the posterior urethra.

In this way the separate fluids from the three portions of the urinary tract can be obtained mechanically. If it is desired to go into further detail the prostate may be massaged and 2 ounces of fluid thereafter passed into *Glass No.* 4; this will show the prostatic condition after massage.

Wolbarst's Five-glass Catheter Test.—The originator of this test describes it as follows:[24]

"The patient presents himself with a full bladder, having retained the urine for several hours—the longer the better. The meatus is cleansed so as to remove adherent secretions. The anterior urethra is first irrigated with a bland solution or sterile water, the washings being collected in a clean receptacle held between the legs. Either a hand syringe or an irrigator may be employed. In the average case of chronic urethritis, from 3 to 5 ounces of irrigating fluid are usually sufficient to thoroughly empty the anterior urethra of its inflammatory products. The washings are poured into a clean glass cylinder, designated as *Glass No.* 1. One or more subsequent washings determine the fact that the urethra is absolutely clean as far back as the 'cut-off muscle.' The clean washings are poured into a second cylinder, designated as *Control Glass No.* 2.

"A sterile catheter of fine caliber is now introduced into the bladder, and an ounce or two of urine drawn off into *Glass No.* 3. This is bladder urine, obtained without contact with either the anterior or posterior urethra. Should this urine be of normal appearance, clear and sparkling, we *know* that the pus and shreds heretofore detected are not from the bladder or upper urinary tract. The catheter being withdrawn the patient voids 1 or 2 ounces of urine into *Glass No.* 4 (posterior urethra). If the pus or shreds appear in this urine, it conveys the information that the origin is in the posterior urethra, since both bladder and anterior urethra have been previously eliminated. If, however, the prostate be normal, the urine passed over the cleansed anterior urethra will be as clear as the catheter specimen from the bladder. After vigorous prostatic massage, the patient voids into *Glass No.* 5, giving us 'massaged prostatic urine.'

"If still further information is desired, each seminal vesicle may be separately massaged and the urine thereafter passes into *Glasses Nos.* 6 and 7, but because of the difficulty of differentiating between prostatic and vesicular secretions the originator does not regard the data supplied by these last two glasses as especially valuable.

"If the urine drawn off from the bladder by the catheter is not clear, the bladder should be completely emptied, and thereafter irrigated with a bland solution until the washings come out clear. When 5 or 6 ounces of sterile water or boric acid solution have been injected through it, the catheter is withdrawn and the test proceeds as before."

If the patient's trouble is in the upper urinary tract the cystoscope and ureteral catheter will, of course, have to be relied on to establish the diagnosis, but the five-glass test prepares the way for investigation of this part of the tract by eliminating the lower part as a possible source of blood or pus.

Source of Pus in the Urine.—A slight variation of the method just described will often be extremely serviceable in determining the source of pus in the urine. It is really an extension of the classical Thompson Walker two-glass test, the starting point being the second glass of that test, to be employed in those cases where this second glass presents a

cloudy content. This is termed *Glass No.* 1 of the test we are about to describe.

Glass No. 2 is obtained by washing the bladder with clear sterile boric acid solution, and the contents of this glass is recorded as "clear" when one or two washings of the bladder cleanses it thoroughly so that the returning solution when caught is the collecting glass, is clear and shows no cloud. It is recorded "slightly cloudy" when more than two washings are required to thoroughly cleanse the bladder, or in other words, when water from the third filling of the bladder is cloudy when caught in the collecting glass. *Glass No.* 3 is obtained by leaving the catheter in place and collecting a specimen through it, and is recorded as clear when it shows no cloud when examined by transmitted light, but appears like normal urine. If cloudy to the eye, it should be examined, for the cloud may be due to factors other than pus.

Seven-glass Test.—The seven-glass test is especially useful as a means of recognition of prostatic disease as differentiated from disease of the seminal vesicles. The two seminal vesicles and the ampullæ of the vasa deferentia being widely separated from each other, as well as from the prostate into which they both empty, it becomes possible to massage one vesicle with its corresponding ampulla, and then the other, manipulating each organ quite separately from its fellow as well as from the prostate below, "provided that the massage is applied only to the upper two-thirds or four-fifths of the organ and avoids with exact caution their confluence just before they enter the base of the prostate at its middle line."

The patient should, if possible, retain all urine for at least five hours. If bladder irritability renders this impossible, the viscus must be distended with sterile normal saline or sterile boric acid water. It is very important to have copious specimens—not less than 150 cc.

Glass No. 1, also called the anterior urethral glass, is secured by laying the patient on the table with suitable sterile towels and a Wolbarst basin between the thighs. After cleansing the meatus a 12- or 14-French, velvet-eye, soft, rubber catheter or blunt-point lisle or silk catheter is very gently passed to the bulb, where it is held in the urethra by the left hand, of which three fingers support the penis, the thumb and index finger retaining the catheter. The right hand takes the 50 cc. Janet-Frank syringe filled with warm sterile boric acid water or normal salt solution, and slowly irrigates the anterior urethra from behind forward, the fluid flowing into a large sterile glass resting in the basin.

Glass No. 2, the anterior urethral control glass, is secured in exactly the same manner, both these glasses thus showing mostly the contents of the anterior urethra, either as pus or shreds, by exfoliation or unhealthy glandular secretion, or all combined. The urethra should be gently massaged upon the catheter while it is in place, in order to express and dislodge as large an amount as possible.

The patient next passes 100 to 150 cc. of bladder urine into *Glass*

No. 3. If the bladder is normal, this glass will show mainly the contents of the posterior urethra, and in uncomplicated cases the microscope will reveal in it the products of posterior urethritis, or in the presence of complications, drainage products from the prostate and seminal vesicles. If there is reason to believe that pus is in the bladder as well as disease existent in the posterior urethra, it will be better to proceed as in the Wolbarst five-glass test, passing a catheter into the bladder for *Glass No.* 3, followed by vesical irrigation.

Glass No. 4, likewise known as the bladder glass, is catheterized gently, employing another catheter of the same kind as that used for irrigation of the anterior urethra. A few cubic centimeters in this glass is all that is needed to permit microscopic search for evidences of pyuria, and if these be found, to determine whether the pus has a vesical or renal origin.

For *Glass No.* 5, the prostatic glass, the bladder should be well filled with fluid, so if an insufficient quantity of urine now remains in the bladder about 500 cc. of sterile normal salt solution or boric acid solution should be run in while the catheter is still in place. The prostate is now carefully massaged along the lateral borders of the lateral lobes, avoiding the course of the ejaculatory ducts along the urethra at the middle of the prostate. The satisfactory performance of this massage is an absolute essential to the proper carrying-out of the test. Following the massage the patient voids 150 cc. of urine, thus presenting prostatic secretion for examination.

Glass No. 6 is the first seminal vesicle glass, designated according to the side from which it is taken. Pedersen,[24] who worked out the details of this test, begins with the side which appears less diseased, or the normal one if the pathological condition is unilateral. The products of the massaged vesicle are now evacuated by the patient into *Glass No.* 6.

Glass No. 7 is filled in the same way from the opposite side. Sufficient fluid should always be kept in the bladder to permit the evacuation of at least 150 cc. into each glass.

Two-stage Seven-glass Method.—It is sometimes desirable to perform the test just described a second time, and it may then be done in two stages—the first stage going as far as *Glass No.* 6, while *Glass No.* 7 is reserved for a subsequent visit.

"The seven-glass test requires, first of all, digital skill in massage as such, and then with the parts of the prostate and seminal vesicles which are to be reached, and with those parts of the same organs which are to be avoided during the massage which this test delimits."

CATHETERIZATION OF THE BLADDER.

"Catheterization" remarks Legueu, "ought always to be looked upon as a surgical operation." The natural corollary to this is that the preparation for it should be the same as for any other operation.

Bacterial Immunity of the Bladder. Normally the urine contained in the male bladder is sterile, though the anterior urethra has frequently been shown to be the habitat of different varieties of bacteria. The investigations of Guyon and his French co-workers have however, fully demonstrated that in a normal male no organism can ascend the deep urethra far enough to penetrate the bladder without some mechanical aid. In the shorter female urethra such spontaneous infection may be possible. It has been pointed out by Fuller[12] that the columnar structure of the epithelium of the deep urethra is peculiarly adapted to resist the encroachment of germs. It is only when one or several gonorrheal infections have so changed its normal qualities that it has become smooth and pavement-like, that this power of resistance is in a measure lost, thus permitting a spontaneous infection of the bladder to take place along the male urethra.

Possible Sources of Infection.—Pathologically, the urinary tract may be infected from one of three sources: (1) From along the urethra (ascending infection); (2) from the kidney, the infecting organisms passing through the secretory structures (descending infection); and (3) from some focus of infection outside, the organisms penetrating the walls of the urinary tract. In the great majority of cases the infection is ascending, and is, far too frequently, due to the passage of instruments. The great importance of perfect asepsis seems hardly necessary to dwell upon, but experience demonstrates that no matter how frequently this caution is voiced, just as frequently some seemingly trivial precaution is omitted and infection is the result.

Preparation of Patient.—The examiner's hands must be prepared in the accepted surgical manner, and the use of rubber gloves, especially if a number of patients are to examined in succession, greatly facilitates keeping the hands in proper condition. It is customary to cleanse the glands and prepuce with green soap and warm sterile water, and to flush the anterior canal with a 2 per cent boric acid, or a 1 to 8000 permanganate solution, or oxycyanide of mercury 1 to 6000 may be used if preferred. Many urologists first swab out the meatus and anterior urethra with the antiseptic solution. In passing a catheter, as with any other urethral instrument, the operator must use the greatest deliberation and gentleness, to avoid irritation or trauma of the sensitive tissues.

Care of Catheters. All catheters, whether of metal, rubber or woven material, should be boiled in water both before and after use. Only those flexible woven instruments which are sufficiently well made to withstand boiling, should ever be employed. If steam sterilization is used the catheters should be exposed to the steam for at least one hour, and in drying woven instruments it must be impressed upon the person in charge of the sterilizing that each instrument must be kept separate from the others while soft, that is, until thoroughly dry.

A Simple Catheterizing Method.—A method of aseptic catheterization employed[16] during the World War in the Italian army, offers some

advantages because of its simplicity and the ease with which even the patient himself may accomplish it.

The catheter is kept rolled up if the container is small in a jar containing a 15 per cent solution of tragacanth. Before being inserted it is boiled in a like solution for about five minutes. A pair of thumb forceps, the points of which have been sterilized, either by immersion in the boiling solution, or by passage through a flame, is employed to remove the catheter from the container, and to unroll it while the end opposite the tip is held between the index finger and thumb of the left hand. The patient holds his glans penis at a right angle to the scrotum and compresses the glans between the thumb and index finger of the right hand, so as to open the meatus. It is, of course, much better to have the gland opened by some one other than the one who is to insert the catheter, but in emergency the patient can serve himself entirely. The catheter is seized with the forceps about 2 cm. from the tip, and the tip introduced into the meatus, and with the help of the forceps pushed along the urethra. The catheter should be pushed into the urethra until the forceps almost, but not quite, touches the meatus, then the forceps is released and a new hold taken 2 or 3 cm. farther back on the catheter. This maneuver is repeated until the tip of the catheter reaches the bladder, its entrance being signalized by the appearance of urine at the outlet.

To preserve asepsis, the tip must be inserted in the urethra without being allowed to touch the meatus, and as the catheter is being pushed into the urethra it must never be allowed to touch the meatus, always stopping a little short of so doing. This technic is so simple it can—as its author puts it—"be employed by anyone having a little common sense." It avoids the danger of introducing an irritating antiseptic, and by boiling the tragacanth solution, lubrication of the entire catheter is obtained, which makes introduction easy. The solution is prepared by soaking a small amount of the tragacanth over night in water, 1 part of tragacanth to 15 parts of water, and then boiling for a few minutes after the addition of a proportionate quantity of boric acid.

In passing the female catheter, rather more difficulty may be experienced in obtaining and maintaining perfect asepsis, because of the likelihood of pathogenic organisms infecting the meatus from the closely associated vulva.

Technic of Bladder Catheterization.—It is always well to remind oneself that the introduction of a catheter into the bladder is, as Legueu says, a surgical operation, and that it should be performed with all due precautions as regards asepsis, and the ever-present possibilities of neglect of these precautions. The examiner should stand at the left of the patient who lies upon the table with his head and shoulders slightly elevated, the thighs flexed, and the knees somewhat separated. With his left hand the examiner grasps the penis, drawing it up toward the abdomen until it is perpendicular in the median line, and the lips of the meatus sufficiently separated to admit the catheter. In his

right hand the examiner holds the catheter, the end of which is now introduced into the urethra and gently pressed forward until it has advanced as far as the bulb. When the eye of the catheter has passed through the internal sphincter and is actually in the bladder cavity, its arrival will be signalized by sensing the fact that the tip is free, and also by the escape of urine down the catheter tube.

In catheterizing normal bladders as well as in disease, we must remember that the bladder empties by the approximation of the anterior to the posterior walls, and the rising of the bottom and the lowering of the top of the viscus in such a way as to form a Y-shaped triangular figure in section when the bladder is empty. It may be seen that if the catheter is introduced too far into the bladder, its eye is likely to be obstructed by a collapse of the walls over its end. If in such cases the catheter is slightly withdrawn, we will obtain more fluid from the incompletely emptied viscus. A good plan in emptying the bladder is to withdraw the instrument slowly as the fluid flows off, so that the eye of the catheter may keep pace with the contracting walls.[15]

No more than 16 ounces of residual urine should under any circumstances be taken when making an examination of the bladder, for as a result of the withdrawal of a larger quantity serious congestion might arise either in the bladder itself or in the kidneys. The Bumpus plan of gradual reduction of vesical pressure is very satisfactory.

Diseased conditions often make the introduction of the catheter difficult, if not altogether impossible. The eye of the instrument may be occluded by clots, shreds of tissue, mucus, or even vesical stones, or a sudden involuntary contraction may take place, which will dislodge the instrument and force it back into the urethra outside of the internal meatus. If the bladder is very toneless, it may be necessary to exert a slight pressure upon the hypogastrium. The extent of the contractile power can be judged quite accurately by observing the stream of urine as it flows from the end of the catheter; a steady curved stream indicates that bladder tone is still good.

Shape of the Catheter.—The shape of the catheter used is a matter of prime importance. If it is to enter the bladder properly, the catheter, after passing the bulbo-membranous junction, must correspond in shape to the curve at this point. The steel and some of the silk instruments come already curved, either following the normal curve or made to correspond to any possible deviation from the normal curve of the urethra, such as might be caused by prostatic hypertrophy. The straight instruments, being flexible, can be made to assume the proper shape by the pressure from the urethra in its curved portion. In the pendulous portion of the urethra, which is straight from the meatus to the bulbo-membranous junction, a straight instrument, if flexible, will penetrate as far as the bulbo-membranous junction, but after this point is passed, a fixed canal is encountered, and to handle the instrument here so as to cause the least possible irritation, or, the instrument having entered the bladder not to push it so far back into the

bladder as to cause injury to the posterior wall, requires considerable dexterity on the examiner's part.

Neurotic individuals are very likely to exhibit sensitive points in the anterior urethra, even if little or no organic disturbance exists. Under such circumstances, any possible pain will be considerably lessened by using a generous amount of lubricant, and passing the instrument very slowly; by grasping the glans penis and extending the urethra, and at the same time pressing on the bulbo-membranous junction with the finger over it on the perineum, so that the angle will become a little less acute where the pendulous urethra joins the beginning of the fixed curved portion of the urethra.[15]

A contraction of the sphincter urethræ muscle may offer resistance to a straight instrument when it has passed easily up to the bulbo-membranous junction, even if no actual stricture exists. Neurotic patients are more apt to present this difficulty, or those patients on whom the catheter is passed for the first time. By elongating and depressing the penis, so as to put the urethra "on the stretch," and by making slight perineal pressure, this obstruction can generally be overcome even with a straight instrument. Care should be observed not to exert too much pressure, and to direct it properly. The floor of the urethra at the bulbo-membranous junction is the section of the canal most likely to be injured, no matter what type of instrument is being passed.

When using either straight or curved instruments care should be taken to keep close to the roof of the urethra until the instrument has entered the curved portion, pushing forward with a slow and gliding movement; whether the instrument is passed by the operator or by the patient himself, it must be remembered that the end of the catheter should find the anterior opening of the fixed portion of the urethra.

Ordinarily, when a catheter, either straight or curved, enters the bladder, this is evidenced by the relaxation of the contracted muscle, or by the escape of a small quantity of urine from the end of the catheter. In thin subjects, this fact may also be easily determined by placing the palm of the hand on the abdomen above the pubes, when the beak of the instrument can be felt against the hand if a curved metal sound or catheter has been used. If doubt exists, 3 or 4 ounces of fluid may be injected through the catheter by means of a syringe. If the fluid runs into the bladder, ordinarily it will return through the catheter when the latter is depressed. If it does not run out again through the catheter on depressing the penis, it demonstrates that while the curved portion of the urethra may have been reached, the instrument has as yet not pushed far enough along the urethra to meet the bladder. If the fluid injected is not returned through the end of the catheter when depressed and does not remain in the bladder, but runs out of the meatus beside the catheter, it is evidence that the curved portion of the urethra has not been passed, and that the compressor urethræ muscle has not relaxed.

In passing coudé (elbowed) catheters, cystoscopes and dilators with very short curves, the necessity for depressing the penis while on the stretch, farther between the legs in order to make the curved portion enter the curved portion of the canal, is greater than in the use of the ordinary instruments. In the presence of stricture the expert can be somewhat more heroic in his methods of pushing the instrument through the obstruction into the bladder than can one who has had less experience. In such cases however, it is a fairly safe rule to let the beak of the instrument hug the roof of the urethra very closely.

Soft-rubber Catheters.—There is a general impression that attempts at passing a soft-rubber catheter, whether made by the surgeon or by the patient himself, can result in no harm, even when the efforts to make the instrument enter the bladder prove to be futile. This view is an erroneous one, for the soft-rubber catheter is inclined to double up at the bulbo-membranous junction, and if force is exerted may bring about trauma which, even when slight, may be sufficient to start up an infective process. If it is found impossible either for the operator or for the patient to pass a soft-rubber catheter, an attempt should be made either to introduce a coudé catheter, or one of the flexible olive-pointed French silk instruments.

The Erect Position.—Occasionally any difficulty that may be experienced in passing a catheter or sound with the patient in the prone position may be overcome by having him assume the erect posture. This latter position may be preferable in two classes of patients—those in whom a spasm of the compressor urethræ muscle exists, and those who present a pocket at the bulbo-membranous junction. Some patients, especially neurotics, are more successful in passing the sound or catheter for themselves than is the medical attendant, and can accomplish it with less distress. In individuals having a pocket at the bulbo-membranous junction the instrument, when its handle is depressed, seems to engage in the pocket instead of entering the fixed portion of the curved urethra. If, while the handle is depressed, the instrument is pulled outward for $\frac{1}{4}$-inch—very gently—so that the beak comes up a little more on the roof of the urethra, and the handle is again depressed, the beak will very often find its way into the curved canal. Pressure on the perineum over the beak of the instrument, exerted by the fingers of the left hand, aids under such conditions. Such difficulties are often encounted in old men in whom the urethra exhibits a tendency to sag down at the bulb.

The most important factors in bladder catheterization may be summed up in the admonition: Take plenty of time and be exceedingly gentle; haste and roughness are alike inexcusable.

Determination of Residual Urine.—When there is reason to suspect retention of urine from any one of the several causes which produce this condition, measures should be taken to estimate exactly how much urine remains in the bladder. This is accomplished by having the patient pass his urine voluntarily and when he has voided all that he

can, to immediately pass a soft-rubber catheter to draw off any urine which has not been expelled by voluntary effort. If no more than a few drams can be obtained in this way it will serve to show that there is very little, if any, retention. But if the amount obtained bears any high proportion to the normal urine content of the bladder of an individual of the age and size of the patient under examination, it indicates a marked degree of retention, bearing a direct relation to the quantity of urine which cannot be voluntarily voided.

CATHETERIZATION OF THE URETERS.

The catheterization of the ureters is a development of cystoscopy and will be further discussed in relation to that subject. The use of the ureteral catheter is, however, one of the most important means of urinary diagnosis, so that a description of its employment in this connection finds a logical place here.

The modern cystoscope is a catheter-like instrument of metal equipped with an incandescent electric-light bulb on the end intended for insertion into the bladder. It is also provided with lenses, a prism and a mirror arranged for optical magnification of the field of vision. An irrigator for the bladder and an apparatus for the accomplishment of ureteral catheterization, are likewise attached to it. In the early days of ureteral catheterization the procedure was looked upon as dangerous except in the hands of experts[20] as well as more or less uncertain in its results, but the improvement of instruments and greatly increased skill in their manipulation, has largely done away with these objections. It is now considered safe to catheterize the ureter if the bladder is sound, and if due attention is given to the maintenance of strict asepsis, though extreme care must always be exercised when the tip of the instrument reaches the renal pelvis, for if too much force be brought to bear the tissues may be bruised sufficiently to cause more or less serious bleeding.

Technic of Ureteral Catheterization.—The ureteral catheters usually employed are long, flexible, hollow tubes made of woven silk covered with shellac, provided with an eye at one end and an opening at the other, the opening serving to permit the passage of urine from the kidney or ureter through the lumen of the catheter to the container which is placed at the other end to receive it. These catheters must be so constructed as to be capable of repeated sterilization. This is best done in an autoclave, but if this is not possible, they can be made properly aseptic by immersing them for six or seven hours in a 4 per cent formalin solution, after which they are thoroughly rinsed in sterile water and wrapped in aseptic covering until used again. They may also be subjected to nascent formaldehyde gas.

The position of the ureteral orifices having been established through the cystoscope, this instrument is now turned toward them by the examiner, who, with the most strict attention to asepsis, now grasps

the sterile catheter, inserts it in the ureteral opening and pushes it up the lumen of the ureter for several centimeters. In any manipulation of this sort it is well to keep in mind the counsel given to his pupils by the great French urologist Guyon: "Always regard all urological instruments, such as the bougie, the sound and the catheter, as but extensions of the fingers, were these so formed as to be able to penetrate as far as the instruments." Great tactile acuity can be attained only by long practice, but even experienced urologists differ greatly in their powers of "sensing" the progress of the instruments they are employing.

Indirect Cystoscopic Method.—Ureteral catheterization by means of the indirect cystoscope is perhaps the method most used at present in the United States. It permits the routine employment of synchronous ureteral catheterization, thus putting at the clinician's disposal the great diagnostic aid afforded by the simultaneous collection of urine from either kidney, and the application of those cultural, chemical and microscopic tests which are now regarded as indispensable to the fully established diagnosis. The "catheterizing telescope" designed by Buerger is equipped with a pair of No. 6 (French) ureteral catheters, connected with a sheath, an observation telescope and an obturator. After the ureteral orifice has been located, the eye-piece of the cystoscope is brought a little toward the patient's opposite side and the shaft raised until the ureteral slit appears slightly below the center of the field. In this position, which it is important to keep exactly, the mouth of the ureter is seen at approximately its natural size, at a distance of 1 to $1\frac{1}{8}$ inches from the objective.[21]

The deflector is now raised just enough to keep the catheter a little away from the lens and the catheter itself pushed forward until it is from 1 to 1.5 cm beyond the field limit, and lies so near the prism as to appear enlarged. As the deflector is raised the tip of the catheter comes into view, traveling upward from the bottom of the field, while it appears to be gradually diminishing in size. When the tip is seen a short distance above the ureteral orifice, it is probably in the right position, though actually it is nearer the vesical neck than it appears, and lies slightly toward the inner side of the ureteral orifice. The shaft of the catheter is now raised so that the tip can enter the mouth of the ureter, and as soon as it is engaged the tip is pushed forward a short distance, the deflector depressed, and the ocular raised to facilitate introduction.

Certain variations of this technic will be necessary in difficult or anomalous cases.[1] It may be necessary to change the amount of deflection or to retain the maximum deviation while pushing the catheter along the ureteral canal. If a stiff catheter is being used and the deflector chances to be turned down too far, the catheter will have a tendency to seek a higher level and the bladder wall will be observed to rise considerably as the tip enters, which indicates that the anterior wall of the ureter is being lifted up by the catheter. This may be overcome in one of three ways, by raising the ocular so as to bring the ureters

more nearly in the direction of the ureteral canal, or by increasing the deflection, or a combination of both.

In general, no matter what method is followed in ureteral catheterization, certain cardinal principles must always be observed. The ureteral orifices must first be located through the cystoscope, and the catheter brought into the field of vision and inserted. The utmost care and delicate manipulation are necessary to avoid harm to any of the highly sensitive tissues involved, and keen judgment is required to be able to note the exact instant the tip of the catheter comes in contact with the renal pelvis. The examiner's eye must constantly mark the progress of the catheter into the lumen of the ureter, which is made possible by markings provided upon all ureteral catheters. Should the bladder become clouded after the first kidney has been catheterized, the field can be cleared by the irrigating attachment to the cystoscope, which permits the evacuation of the bladder and its refilling with fresh fluid.

Advantages of Separate Catheterization of the Ureters.—The perfection of the technic which made possible separation of the urine from either kidney was a tremendous forward stride in the diagnosis of all types of kidney lesions. Before that, the segregator had been the only instrument which enabled an examiner ever to attempt to separate the urine of the two kidneys. The principle of this instrument has been aptly described by the Australian urologist, Gordon Craig,[7] as consisting "in the raising of a water-tight bulkhead, which divided the bladder into a right and left compartment."

From each lateral pool, a device was arranged whereby a specimen for urinalysis could be withdrawn. The theory of the segregator or separator was a good one, but in practice, it was often impossible to prevent the urine on one side from running under or over the dividing wall, and contaminating that of the other side. But, as Craig remarks, "if this instrument failed in its immediate object, it at least established the all-important fact that, unless a collecting tube is passed into each ureter, accurate and reliable information cannot be gained about the individual kidney." Catheterization of the ureters is however, only one link in the chain of evidence by which we must establish a diagnosis in any case presenting urinary symptoms. Sometimes it will not be necessary. Kelly has had made an oblique speculum which can be held under the ureteral orifice, so as to catch the urine as it spurts down the lumen, by means of which he is enabled to secure a few drops of urine sufficient for a chemical or bacteriological examination direct from the kidney without using a catheter. The ordinary No. 10 speculum may also be used for this purpose.

Yet the evidence gathered by a careful catheterization of both sides may be just the missing link in our chain of evidence, without which the diagnosis cannot be established. Its greatest usefulness is in locating pyogenic and hematuric affections of the kidney: and stricture or ureteral calculi may often be found by this means. Craig points out that from the patient's point of view at least, perhaps the greatest of

all its uses is in the determination of an absolute negative so far as the existence of kidney disease is concerned.

Difficulties of Ureteral Catheterization.—Most descriptions of the technic of ureteral catheterization would lead one to believe that the ureteral openings bear as definite a relation to the bladder orifice as does the tip of the nose to the eyes. As a matter of everyday practice, this is actually very seldom the case. The normal relation of the three points is an isosceles triangle, the urethral orifice being at the apex and the ureter opening at each end of the base. But often, after pelvic inflammation or obstetric injury to the pelvic floor, the ureteral openings will be considerably dislocated. Perhaps one orifice will occupy its normal position, while the other will be some distance from the place where one would normally expect to find it. Again, inflammation of the bladder mucosa near the ureteral orifices may cause so much swelling that they will be wholly invisible through the cystoscope, and must be searched for by probing the edematous mucous membrane with the end of the catheter. The ureteral orifices are more likely to be out of position in parous women; also in advanced tuberculous vesical ulceration occurring in male patients, the distortions resulting from cicatricial contraction may serve to conceal the ureteral opening from all but the most acute and perservering observers.

Time Required for Ureteral Catheterization.—When no difficulty is experienced in finding the ureteral openings, a specimen of urine may usually be collected in twenty minutes from the moment the cystoscope is first introduced. In different individuals, the length of time before the first drop appears at the end of the catheter will vary considerably. The flow is retarded by such extraneous agencies as morphine or anesthesia, and psychic factors probably exert some influence as well. Under normal conditions each kidney secretes about an ounce of urine in an hour, so that as soon as the flow through the catheter is fully established, one can make an empiric estimate of the relative activity of either kidney.

Uses of Ureteral Catheterization.—The uses of ureteral catheterization are so obvious that it seems almost superfluous to attempt to enumerate them. Beside those which accrue from the ability to submit the urine from either side to a separate examination, the following may be mentioned: By the employment of the ureteral catheter the urologist is able to estimate the functional power of the urinary apparatus, either a polyuria, or an oliguria; or again by a failure to respond to the stimulus exerted; it will also demonstrate entire loss of function. When hydronephrosis or pyonephrosis is present this method will not only establish that fact, but will permit a fair estimate of the size of the tumor to be made, as fluid may be injected until the renal pelvis is distended as much as possible, and the fluid then withdrawn; subsequent measurement of the recovered fluid giving accurate data in regard to the capacity of the sac. This same operation can be made to induce an artificial renal colic, which can be identified with or

possibly distinguished from the "pain in the back" or "side," which the patient has heretofore been unable to locate.

The mere insertion of the catheter is often sufficient to stimulate an inactive kidney so that secretion will be resumed in response to the pelvic lavage, and the catheter often serves as a passage way for therapeutic irrigations and injections. Not infrequently the instrument will serve to dilate a stricture, or to make possible the passage of urine which has been obstructed by the growth of a neoplasm. In radiology of the urinary tract it serves to convey the opaque medium, and left *in situ* after being filled with some substance impervious to the roentgen-rays, it enables the observer to distinguish external concretions or phleboliths from calculi located within the ureter itself. These applications will be considered in detail in a later chapter.

EXAMINATION OF THE URINE.

Microscopic Examination.—It is only within comparatively recent years that microscopic examination of the urine has been regarded as of any especial value and importance. Chemical analysis has been carefully carried out during a long period and it is still undoubtedly true that in the majority of cases simple chemical examination will answer every requirement. But in most of the cases which reach the urologist conditions are such that this alone will not suffice, and even to the general practitioner, sufficient knowledge and ability to carry out microscopic examination when necessary, are absolutely essential.

Pus.—If pus corpuscles are found in the urine, even if they are very few in number, they are a positive indication that a pathological process is at work somewhere in the urinary tract. If they are present in very small amounts it may be that nothing more than an irritation exists; if more numerous we may be sure that we are dealing with an inflammation; while the presence of a great quantity points positively to a diagnosis of ulceration or suppuration, which must however, still have confirmation from other sources of diagnostic data.

Epithelial Cells.—Three kinds of epithelial cells, flat, cuboidal and columnar, are found in the genito-urinary tract. Sometimes the epithelial lining will be a single thickness; again it will be stratified into three layers, and it is where the lining takes this form that we may find all three types of cells at one point, the deepest layer directly adjacent to the connective tissue being made up of columnar cells; the cuboidal composing the middle layer; while the top stratum is formed from flat cells.

In healthy individuals the excreted urine will be found to contain a certain number of flat cells desquamated from the bladder in both sexes, and in the female from the vagina also. If other types of epithelia are found they are of pathological origin.

Flat epithelia are irregular in outline, presenting a broad front surface; cuboidal are round or oval, having the same diameter in all

directions, while the columnar are elongated in one direction or rather cylindrical. All epithelia are granular with one or more nuclei, which may or may not be seen, or else may have dropped out leaving a vacuole. The granulation is either coarse or fine; the flat are finely granular, the columnar coarsely so; while the cuboidal present an intermediate degree of granulation. Epidermal scales from the prepuce in the male and the clitoris and labia in the female, or sometimes from the fingers of the examiner while handling the slides and covers, may occasionally introduce an element of confusion. These however, should be easily distinguished from epithelia as they contain no nucleus and are highly refractive, presenting a jagged outline.

If one observes cuboidal and columnar epithelia which contain fat granules and globules resembling those seen in pus corpuscles, it may be taken as an indication that the conditions giving rise to them are chronic ones. Prolonged irritation such as is caused by the pressure of a tumor, will often produce epithelia containing a number of nuclei, even as high as five, usually designated as *endogenous pus corpuscles* or *new formations.*

Connective-tissue Threads. If threads of connective tissue are present in the specimen it is an indication that the pathological process has penetrated below the epithelial lining. Under the microscope these fibers appear moderately refractive, the wavy threads being combined in small bundles, sometimes so minute as to be barely visible even under a 450-lens, or again so large as to occupy a great part of the visual field. "Connective-tissue corpuscles" is the name applied to those threads which have a granular appearance and contain formations within them which bear a certain resemblance to nuclei.

In the diagnosis of cancer, papilloma or sarcoma, the presence of these threads in the urine is of the utmost significance. In ulcerative processes they will be of considerable size and very abundant, and when present in considerable number and accompanied by pus cells, indicate suppuration or abscess formation. In vesical cancer we may see "cauliflower" threads, very large with numerous inflammatory corpuscles, especially if the neoplasm be of the villus type. The shreds from papilloma are branched, containing numerous inflammatory corpuscles, while those of sarcoma are also large, "seen as groups of glistening coarsely granular corpuscles, non-nucleated, at times almost hemogenous, smaller than the pus corpuscles and larger than red blood corpuscles," the threads containing them being likewise of considerable size.[14]

Examination of Stained Specimens. When attempting to employ staining methods for the detection of tubercle bacilli in the urine, the examiner is often hindered by the density of the bacillus and the presence of pus and detritus. But as there is a marked difference between the density of tubercle bacilli and of pus, it has been found possible to concentrate all the bacilli present in a considerable volume of urine so that cover-glass preparations may be made in which the

bacilli will be found very readily as they are not hidden by a large number of cells. The required technic is as follows:

When a relatively large amount of pus is present in the urine the specimen should be centrifugated for a minute or two at the lowest speed. A heavy sediment of pus and detritus will thus be thrown down, the urine remaining above appearing cloudy and holding in suspension a small number of pus cells and practically all the bacilli contained in the specimen. The urine should now be decanted into a clean tube, the sediment discarded and the specimen again centrifuged at high speed *until it is clear*, which will require from fifteen to twenty minutes. The urine may then be decanted and the tube containing the sediment refilled with partly clarified urine and again placed in the centrifuge, this procedure enabling the examiner eventually to concentrate the contents of several tubes of urine into a single sediment of small bulk. Finally clear urine should be poured off and the tube inverted over an absorbent cloth which will take up the last moisture leaving the remaining sediment practically dry, so that it can be manipulated with a loop and removed for cover-glass preparation or culture.

By centrifugalizing the urine until it is clear, deposit of the bacteria is assured. This method is useful in determining the nature of the infections other than tuberculous. The performance of the Gram stain, or the Ziehl-Neelson stain if indicated, will quickly show whether infection is present, and in addition provide sufficient data in respect to the nature of the organisms involved to permit the proper cultural procedures to be carried out.

Staining. The sediment finally obtained should be spread upon a clean glass slide, aërated until absolutely dry and then passed three times through a flame for fixation. If the search is for tubercle bacilli, stain the specimen as in examination of sputum, which is commonly done by steaming in carbol-fuchsin for three minutes; removal of excess stain by flushing with water, decolorization and counter-staining with Gabbet's* solution (made by the combination of 100 cc. of 25 per cent sulphuric acid with 2 grams of methylene blue). The slides should be held in this solution only one minute, then quickly washed in plain water, dried and immediately examined.

The discovery of acid-fast bacilli in such a specimen does not invariably mean that a tuberculous infection is present. The smegma bacillus, an organism very frequently found in the deep urethra in the male, and the anterior portion of the urethra in the female, is also acid-fast, and any specimen obtained in the ordinary way is likely to be contaminated by it. To avoid the possibility of such a mistake guinea-pig inoculation should always be employed as an additional diagnostic test.

Guinea-pig Test.—Two guinea-pigs, which have been proven free from tuberculosis by application of the tuberculin reaction are inocu-

* Some authors do not regard Gabbet's solution as reliable.

lated with the urinary sediment, the injection being made in the first animal directly into the inguinal lymph nodes, and intraperitoneally into the second animal. If, after being under observation for twenty-two days, the animals have neither decreased in weight nor manifested any clinical evidences of disease, they may be considered as offering negative evidence. But if neither guinea-pig dies during this observation period it will be better to retain them for an additional three weeks, and then, after killing them by anesthesia, make a thorough post-mortem search for evidence of tuberculosis. Petroff's method of culturing tubercle bacilli may be employed.

Tests for Staphylococci, Etc.—When it is necessary to search the urinary sediment for bacterial organisms other than tubercle bacilli the urine should be centrifugalized as previously described and the urinary salts removed by washing with sterile water. The residue should be fixed in a flame and stained for a single minute in Roux's blue, for which the formula is:

Solution A.		Solution B.	
Violet dahlia	1 gm.	Methyl green	2 gm.
Absolute alcohol	10 gm.	Absolute alcohol	20 gm.
Distilled water	q. s. for 100 gm.	Distilled water	q. s. 200 gm.

Prepare each solution separately by rubbing up the dye with the alcohol in a mortar and add the water gradually. Let the mixture stand for twenty-four hours in a bottle. Then mix the two solutions, filter and store in a well-stoppered bottle.

Loeffler's methylene blue stain may also be used.

If Gram staining is necessary, as in differentiating gonococci, the following modification is recommended by Gradwohl as a permanent and reliable primary stain superior to the aniline-oil-gentian-violet mixture, requiring fresh preparation for each examination. The urinary sediment is spread, dried in the air, fixed by passing through a flame and stained for sixty seconds with carbol-gentian-violet, made up as follows:

Gentian violet	1 gm.
Carbolic acid crystals	2 gm.
Absolute alcohol	10 gm.
Distilled water	100 cc.

Rub up the gentian violet and the alcohol in a glass mortar, add the carbolic acid and mix; add two-thirds of the water, stirring all the time; pour the mixture into a bottle, then rinse out the mortar with the rest of the water and add it to the mixture in the bottle. Leave for twenty-four hours and filter into a clean glass-stoppered bottle.

Blot up the excess of stain (but do not wash), drop 2 or 3 large drops of Gram's solution of iodine, (iodine 1 gram; potassium iodide, 2 grams; distilled water 300 cc.) on the smear, and allow it to stain twenty to thirty seconds. Wash in water and dry. Pour absolute alcohol over the film a drop at a time until no more violet stain comes away, usually thirty seconds. Wash rapidly in water. Counter-stain for one minute with an aqueous solution of safranin. Wash in water, dry and examine. Gram-positive organisms are stained a deep violet and Gram-negative organisms a delicate light pinkish or safranin color.

The value of stained specimens of the sediment from centrifugation of the urine has been thus tersely summed up by Crabtree:

"Stained sediments serve to distinguish true infections from contaminations, show something of the nature of the infecting bacteria, show the predominating organism in mixed infections, which is not accurately demonstrated by cultures in some cases, and demonstrate the presence of unusual bacteria which are not found by routine cultural examinations."[6]

Cultures.—When searching the urine for gonococci, and less frequently, when it is desired to demonstrate the presence of other organisms such as staphylococci or streptococci, it is often necessary to resort to cultivation. When the gonococcus is obtained from urinary sediment it is not always easy to grow it upon culture media, but other pyogenic bacteria take more kindly to this treatment. The media most commonly employed are Loeffler's blood-serum or blood-serum agar, less frequently, media made with hydrocele or ascitic fluid and agar-agar. Lately it has been discovered that the gonococcus grows well on almost any medium if it is kept moist. This is accomplished by using sterile rubber stoppers in the test-tubes.

EXAMINATION OF THE UNSTAINED SPECIMEN.

Urinalysis, like all other forms of laboratory work, must be accurate in order to be helpful. Unless the results are absolutely dependable, the time spent in doing the work will be far worse than wasted, for the examiner may be misled into all manner of errors. Nevertheless, to use the words of Cummer,[8] "the examination of the urine for clinical purposes can, and should be, reduced to extremely simple terms."

The study of urinary sediments is usually considered under three heads: unorganized sediments, organized sediments and extraneous structures.

Unorganized Sediments.—Unorganized sediments are classified according to the reaction of the urine in which they are most likely to occur. In *acid urine* are found uric acid, amorphous urates, sodium urate, calcium oxalate, leucin and tyrosin, cystin and fat globules. Of these leucin and tyrosin may be regarded as pathologically important, and in certain conditions calcium oxalate occurs in such excess as to be pathologic.

Leucin and Tyrosin.—Leucin and tyrosin generally appear together, though their occurrence is comparatively unusual in any case. When found they are commonly indicative of severe fatty degeneration of the liver, such as accompanies phosphorus poisoning or yellow atrophy. The crystals of leucin appear under the microscope as oily spheres of faint yellow tinge, often showing radial and concentric striations. They are soluble neither in hydrochloric acid nor in ether. The crystals of tyrosin appear as fine colorless needles and most commonly will be

observed arranged in sheaves, the middle portion markedly constricted. Ammonia and hydrochloric acid will dissolve them, but acetic acid has no effect.

Cystin.—Cystin may be found in slight traces in normal urine, as it is one of the amino-acids formed in decomposition of the protein molecule. It is, however, only when this substance is present in the urine in abnormal quantities that any crystals are deposited—this constituting *cystinuria*, a rare condition due to some abnormality of protein metabolism which is at present imperfectly understood. As the condition strongly predisposes the individual to the formation of calculi, any symptoms present will usually be referable to lithiasis. The crystals of cystin are colorless, highly refractive, and appear as somewhat thick hexagonal plates, the edges of which are sharply defined, either singly, or arranged in masses one above another.

Fat-globules.—Fat appears in the urine in very small globules—though the size varies considerably—which are always highly refractive. Osmic acid changes their color to black, while the addition of Sudan II turns them red or orange. Fat globules are a common finding in chronic parenchymatous nephritis, fatty degeneration of the kidney, or phosphorus poisoning, and they may be seen floating free in the urine, or embedded in cells and tube casts.

The phosphates, calcium carbonate and ammonium urate found in alkaline urine are of no pathological importance.

Organized Sediments.—Tube-casts. Albuminous casts of the uriniferous tubules of the kidney appear in the urine only when there is some pathological change taking place in the kidney, although this process may be so slight as to have no clinical importance. We should therefore, regard a cast only as an indication of the state of the particular kidney in which it was formed, but its appearance is by no means an indication of disease of the entire renal organ.

Classification of Casts.—Casts may appear in a number of forms as: (1) Hyaline casts, both narrow and broad; (2) waxy casts; (3) fibrinous casts; (4) granular casts, both finely and coarsely granular; (5) fatty casts; (6) casts containing organized structures, epithelial casts, blood casts, pus casts or bacterial casts.

The examination of epithelial cells and pus corpuscles has already been considered (p. 67). Beside these many extraneous structures are often found in the urine from accidental contamination, such as yeast cells, moulds, fungi, starch granules and air bubbles.

Urea Estimation.—Urea is the chief solid constituent of the urine, as well as being the most important both physiologically and pathologically. Its nitrogenous character is indicated by its chemical formula, which is $CO(NH_3)_2$. A healthy adult will excrete daily from 25 to 35 grams, relatively 500 grains, of urea, so that this one element furnishes practically one-half the solid constituents of the urine. This also represents 85 to 90 per cent of all the nitrogen eliminated by the kidneys.

Urea Test.—Two or 3 ounces of urine are evaporated over a water-bath until the fluid is reduced to the consistency of syrup. If a few drops of pure colorless nitric acid are now added, crystals of urea nitrate will form.

Quantitative Estimation.—The hypobromite method, which is most commonly employed for the quantitative estimation of urea, depends upon the fact that this substance decomposes under the action of sodium hypobromite with liberation of nitrogen, and from the volume of nitrogen thus set free, the amount of urea can be calculated. The Doremus-Hinds ureometer is commonly used for this purpose.

Method.—Pour some of the urine into the smaller tube of the apparatus, then open the stop-cock and quickly close it again so as to fill its lumen with urine. After rinsing out the larger tube with water fill it and the bulb with 25 per cent caustic soda solution. Add to this by means of a medicine dropper 1 cc. of bromine and mix well. This prepares a fresh solution of sodium bromide with excess of caustic soda, which serves to absorb the carbon dioxide set free in the decomposition of the urea. (When handling bromine, keep an open vessel of ammonia near to neutralize the effect of the irritant fumes.)

Pour the urine into the smaller tube, and then turn the stop-cock so as to let as much urine as desired (usually 1 cc.) run slowly into the hypobromite solution. When bubbles have ceased to rise, read off the height of the fluid in the large tube by the graduations upon its sides. This gives the amount by weight of urea in the urine which has been added, from which the amount excreted in twenty-four hours can easily be calculated. If the urine contains much more urea than the normal amount, it should be diluted.

To avoid handling pure bromine, Rice's solution may be used.

(1)		(2)	
Bromine	31 gm.	Caustic soda	100 gm.
Potassium bromide	31 gm.	Distilled water	250 cc.
Distilled water	250 cc.		

One part of each of these solutions and 2 parts of water are mixed and used for the test. The bromine solution must be kept in a tightly-stoppered bottle, otherwise it will lose its strength very quickly.

A much more accurate test for urea is that devised by Prof. S. Kennerly Marshall of Johns Hopkins. For ordinary purposes however the above test is satisfactory.

PHYSICAL EXAMINATION OF THE URINE AND FUNCTIONAL RENAL TESTS.

Not alone must the chemical and bacterial content of the urine be carefully considered in the gathering of diagnostic data, but the character of the urine as a whole and the process by which it is excreted from the body, should undergo thorough scrutiny by every careful examiner.

Physical Examination. 1. **Quantity.** The quantity passed in twenty-four hours varies with the age and size of the patient as well as with the amount of liquids ingested, the perspiration excreted, etc. The normal amount may be assumed to be 1000 to 1500 cc., or from 40 to 50 ounces.

Polyuria consists in the excessive secretion and discharge of urine containing increased amounts of solid constituents. The quantity of urine voided is increased during the absorption of large serous effusions, and in many nervous conditions; also in chronic interstitial nephritis, diabetes insipidus and diabetes mellitus.

Oliguria means deficient secretion of urine. The amount of urine voided is decreased in severe diarrhea; in fevers; and in all conditions which interfere with circulation of blood in the kidney, *e. g.*, poorly compensated heart disease.

Anuria is a condition in which no urine is voided. This includes, (*a*) *suppression*, when the secretion of the kidney is suspended, and (*b*) *retention*, when the fluid, although secreted, is retained in the urinary passages by mechanical obstruction.

Hydruria is a persistent excess of the aqueous constituents of the urine secreted, without a corresponding increase in the solids. This occurs in diabetes insipidus and hysteria, and is also often observed in neurotic subjects.

2. **Color.**—The usual color of freshly voided urine is yellow or amber-hued, due to the presence of several pigments, chiefly urochrome. Even in health, however, the color varies and depends upon the quantity of water ingested. Acid urine is generally darker than alkaline. Vogel's scale of urinary color is widely used, the urine being filtered and examined by transmitted light in a glass 3 or 4 inches in diameter.

Abnormal pigments sometimes change the color. Thus, blood-pigment gives a red or brown, smoky color; bile, a yellowish or brown foam when the container holding the urine is shaken, or it may assume a greenish hue after standing, owing to the oxidation of bilirubia into biliverdin. Methylene blue, ingested in small amounts, gives a pale green shade, while large amounts produce blue. Santonin produces a yellow color, while rhubarb, senna, cascara and other cathartics produce brown. Thymol gives a yellowish-green, and phenol and related drugs cause the urine to become olive-green, varying to brownish-black upon standing, although the color may be normal when voided. The presence of melanin, usually but not invariably due to melanotic sarcoma, gives the urine a brown or black color after long standing.

3. **Transparency.**—Freshly passed normal urine is clear. Upon standing, mucus, leukocytes, and epithelial cells settle to the bottom. Cloudiness is usually due to the presence of phosphates, urates, pus, blood, or bacteria.

Amorphous phosphates are precipitated in neutral or alkaline urine. They form a white cloud and sediment, which disappear upon addition of an acid.

Amorphous urates are precipitated only in acid urine. They form a white or pink cloud and sediment ("brick-dust deposit"), which disappear upon heating.

Pus resembles phosphates to the naked eye, but is easily detected with the microscope, or by Donné's test (adding a strong solution of caustic soda to the sediment, which is thereby transformed into a gelatinous mass).

Blood gives a reddish or brown, smoky color and may be recognized with the microscope or by tests for hemoglobin.

Bacteria, when present in great numbers, give a uniform cloud, which cannot be removed by ordinary filtration. They are detected with the microscope or by culture.

4. **Odor.** The characteristic aromatic odor of fresh urine is due to the presence of volatile acids, and is most marked in urines which are highly concentrated. A "fruity" odor is sometimes noted in diabetes, due probably to acetone. Cystin may develop an odor of sulphuretted hydrogen during decomposition.

5. **Reaction.**—Normally, the urine is acid in reaction. This acidity was formerly held to be due to acid phosphates, but, according to Folin, the acidity of a clear urine is greater than the acidity of all the phosphates, the excess being due to free organic acids. Individual samples may be slightly alkaline, or amphoteric. The reaction is determined by means of litmus paper.

Acidity is increased after the use of certain drugs, and also in fevers, the irritation which they cause producing frequency. This knowledge is of practical importance in considering the enuresis of children.

Upon long standing, urine becomes alkaline owing to decomposition of the urea with the consequent formation of ammonia. If the urine is alkaline when voided, it usually indicates ammoniacal decomposition in the bladder, which is the rule in chronic cystitis, especially when the condition is due to paralysis or obstruction.

Though the quantitative estimation of the acidity of the urine is not of much clinical value, the following test will be found satisfactory when such estimation is desired.

Test for Acidity.—Having measured into a 100 cc. flask 25 cc. urine, add 5 to 20 grams of powdered neutral potassium oxalate, and 1 or 2 drops of a 1 per cent phenolphthalein solution. Shake the mixture well for one or two minutes and titrate it immediately with $\frac{N}{10}$ sodium hydroxide until a faint but permanent pink remains after further shaking. Acidity is expressed in terms of oxalic acid, of which 0.0063 gram equals 1 cc. of the decinormal sodium hydroxide. If 3 cc. of the soda neutralizes 25 cc. of the urine, then the acidity of 100 cc. is three times four times 0.0063, which equals 0.0756, which in turn is the same as 0.756 parts per thousand. The neutral potassium oxalate is used to get rid of disturbing factors, which it accomplishes by precipitating the calcium and magnesium salts as oxalates.

6. **Specific Gravity.**—The normal average specific gravity of urine is about 1.015 to 1.025. Pathologically it may vary from 1.001 to 1.060. For ordinary purposes it suffices to take the specific gravity with a urinometer, which is a spindle hydrometer for liquids heavier than water, carrying a scale ranging from 1000 to 1060, and usually adjusted for taking readings at 25° C.

Method.—Fill to one-half its capacity a cylindric vessel having a level lip. Gently immerse the urinometer and carefully fill the cylinder to the brim with urine. Take the observation by sighting on a level with the surface of the urine, which rises slightly above the edge of the glass. Note the lower surface line and not the point to which the liquid rises by capillary attraction up the side of the scale.

The specific gravity is low in diabetes insipidus, chronic interstitial nephritis, and many functional nervous disorders. It is high in fevers, and in parenchymatous nephritis. In any form of nephritis a sudden fall, with a corresponding increase in quantity of urine, may foretell approaching uremia. Specific gravity is highest in diabetes mellitus, and a high specific gravity when the urine is not deeply colored, should lead one to suspect the presence of this disease. A normal specific gravity does not, however, exclude it.

Total Solids.—It is possible to draw valuable conclusions from roughly estimating the solid constituents of the urine by multiplying the last two figures of the specific gravity with Long's factor 2.60. This gives parts of solids per thousand of urine, and after measuring the number of liters passed in twenty-four hours, furnishes some idea of the efficiency of the kidney at the time. Another rule giving grains of solids, is to take the total number of fluidounces of urine passed in the day, multiply by the last two figures of its specific gravity, and add 10 per cent. Thus, if 50 fluidounces be passed, the specific gravity being 1015, the total solids are found by 50 times 15 equals 750, plus 75 equals 825 grains ($50 \times 15 = 750 + 75 = 825$ gr.). The average amount excreted daily by a healthy male is 75 grams, or 1100 grains.

8. **Functional Tests.**—Accurately ascertaining the functional efficiency of the kidneys, especially of one kidney when removal of the other is under consideration, is a matter of great importance. Such tests are most useful when the urines obtained from the separate kidneys by ureteral catheterization can be compared. The following methods of making these determinations are in use:

(*a*) *Phthalein Test.*—Phenolsulphonephthalein, suggested by Rowntree and Geraghty, has the advantage of being non-irritating, nontoxic, and easily used, and it determines the activity of elimination with mathematical accuracy. From 60 to 85 per cent of the amount used is excreted by the normal kidney in two hours, and the percentage is very simply determined by the use of the colorimeter.

Method.—After ureteral catheters are inserted, the patient is given 300 cc. water, the bladder is emptied and a sterile solution of phenolsulphonephthalein, as the monosodium salt 0.006 gram. in 1 cc., is

injected either into the muscles of the arm or intravenously. Normally, the dye begins to be excreted in from five to ten minutes after intramuscular administration and in from two to eight minutes after intravenous, and almost all of it passes the kidneys within two hours. As the urine is secreted it flows out through the catheter and drops into a collecting glass which has in it some 25 per cent sodium hydroxide. As soon as the alkalized urine turns reddish, excretion of the drug has begun, and the time should be recorded. Samples are collected at the end of the first and second hour, each diluted to 1000 cc., alkalinized, and tested with a Hellige or Duboscq colorimeter, or with the convenient and inexpensive Dunning colorimeter made for this purpose. Normally, 38 to 60 per cent of the drug is excreted during the first hour and 60 to 80 per cent for the two-hour period. The amount of the drug excreted does not correspond to the volume of the urine. Though the quantity of liquid be normal, the permeability to the drug may be much diminished in proportion to the intensity of the kidney mischief. Though uremia may be impending in nephritis, or in the puerperal state, the liquid output may still remain normal in volume.

(*b*) *Phloridzin Test.*—This test consists in the hypodermic injection of a small quantity of phloridzin. In health, this substance is transformed into glucose by the kidneys. In disease, this change is more or less interfered with, and the amount of glucose recoverable from the urine is taken as an index of the secretory power of the kidneys.

(*c*) *Methylene-blue Test.*—In this test of Achard and Castaigne, a solution of methylene blue is injected intramuscularly and the time of its appearance in the urine noted. Normally, it should appear in about thirty minutes, but when delayed, renal "permeability" is supposed to have been interfered with. Since methylene blue is sometimes excreted as a colorless derivative, the use of indigo-carmin in this test has been proposed as a substitute.

(*d*) *Indigo-carmin Test.*—This test is still held by many authorities to be the most accurate of all the functional kidney tests. The method used in foreign clinics is still in vogue.

Method.—Thomas uses 5 indigo-carmin tablets dissolved in 100 cc. sterile water, concentrated down to 20 cc. over a water-bath and bottled in a sterile glass container. Twenty cubic centimeters are then injected into the buttocks, or if to be used intravenously, the solution is sterilized and filtered and then resterilized. The earliest time of the appearance of the dye is about eight minutes. The kidney is considered normal where the dye appears in from ten to twenty minutes.

(*e*) *Cryoscopy.*—The determination of a lowered freezing-point of the urine is regarded as evidence of molecular concentration. The method has many technical difficulties, hence most physicians are accustomed to ascertain the activity of the kidneys in this respect by multiplying the last two figures of its specific gravity, carried to the third decimal place, by the factor 0.075. The specimen must be free from sugar and albumin. Thus, if the specific gravity, carefully taken,

gave the last two figures and decimal as 10.125, then 10.125 times 0.075 equal 0.758 C. which is less than the normal range (1.2 times 2.3).

(f) Creatinin Test.—Creatinin elimination affords not only a determination of renal function, but also the differentiation of structures that are the seat of lesions, from those structures that are free from them; but as this test is very complex it is not practical for the average urologist.

(g) Mosenthal Test-meal for Renal Function.[1]—This test was originally suggested by Hedinger and Schlayer in 1914, and was later elaborated by Mosenthal. The urine is collected during the day at two-hour intervals, the patient partaking of his ordinary diet in the usual amount, but *taking neither food nor fluid between meals.* The bladder should be completely evacuated every two hours, and the specimens kept in separate bottles, properly labelled with the time at which the contained urine was voided. A time schedule should be given to the patient; *e. g.*, he should be directed to collect the specimens at 8 and 10 A.M. and at noon, and at 2, 4 and 6 P.M., and again three hours after the evening meal. Any urine passed after this time during the night should be kept and mixed with the specimen voided in the morning, which would represent the output of ten or twelve hours.

Mosenthal states that under these circumstances the normal response would show a maximum specific gravity of 1.018 or more. The specific gravity should vary at least 9 points between the highest and the lowest readings. The night urine should be small in amount, that is, less than 400 cc. and of high specific gravity, 1.018 or over.

Signs of a diminished renal function are: (1) A lowering of the maximal specific gravity; (2) a fixation of the specific gravity; (3) a nocturnal polyuria. The Mosenthal diet test is easily employed and is of especial value in early cases of nephritis, for it gives positive indications and reaches the highest degree of impairment before other tests.

(h) Ambard's and McLean's Coefficients.—Ambard claims to have shown that the elimination of at least certain substances is carried on by the kidneys according to definite laws which are capable of mathematical expression. These laws he reduced to a mathematical formula known as Ambard's Coefficient. The relative constancy of this as regards the excretion of urea was claimed by Ambard.

The constant ratio between the concentration of urea in the blood and the rate of excretion in the urine, is determined by the following mathematical formula:

$$\text{Constant (K)} = \sqrt{\frac{\text{Ur}}{\text{D} \times \frac{70}{\text{Wt}}}} \times \sqrt{\frac{\text{C}}{25}}$$

Ur = Grams of urea per liter of blood.
D = Grams of urea excreted per twenty-four hours.
Wt = Weight of individual in kilograms.
C = Grams of urea per liter of urine.

[1] This test and the following are taken from Cummer's Clinical Laboratory Methods, Lea & Febiger, 1926.

The standard concentration of urea in the urine is taken as 25 grams per liter, and 70 kg. as the standard weight.

The normal value of the coefficient is between 0.07 and 0.09. In impaired function with inability of the kidney to eliminate in proportion to the concentration of urea in the blood, there is a rise in the constant in proportion to the degree of renal insufficiency. Values of from 0.09 to 0.12 indicate slight impairment, 0.13 to 0.2 a moderate degree of impairment, and above 0.2 severe renal impairment.[23]

The formula has been modified by McLean so that the index may express directly the changes in the rate of excretion. One hundred represents the normal finding and corresponds with a value of 0.08 for Ambard's coefficient. In this country, the McLean index has come into wider use than Ambard's coefficient. McLean's index is expressed as follows:

$$\text{Index} = \frac{\text{Gm. urea per twenty-four hours}) \sqrt{\text{gm. urea per liter of urine}} \times 8.96}{\text{Wt. in kilos.} \times (\text{Gm. urea per liter of blood})^2}$$

In order to secure free excretion of urine, the patient should drink 150 to 200 cc. of water. One-half hour later the bladder is emptied completely, by catheter if necessary. The time is noted exactly to a minute. The urine is collected at the end of seventy-two minutes, *i. e.*, one-twentieth of twenty-four hours. Thirty-six minutes after the beginning of the period, 10 cc. of blood are obtained from the vein of the arm, clotting being prevented by the addition of sodium or potassium oxalate, and the amount of urea determined.

The procedure for determining blood urea is given by Van Slyke and Cullen as follows:[30] Run 3 cc. oxalated blood into a large test-tube containing about 10 cc. ammonia-free distilled water. Add 2 urease tablets (powdered). Leave at room temperature for thirty minutes. Add a teaspoonful of salt, a few drops of foam killer (20 per cent solution of rosin in turpentine), and finally 5 cc. of a saturated solution of potassium carbonate. Drive off the ammonia by aspiration into another tube "B" containing 15 cc. $\frac{N}{100}$ sulphuric acid and 1 drop of alizarin, one hour. Titrate the excess of acid with $\frac{N}{100}$ sodium hydroxide.

Each cubic centimeter of acid neutralized indicates 10 mg. urea per 100 cc. blood; or 4.67 mg. urea-nitrogen per 100 cc. blood. In case the blood is one of the rare samples containing over 150 mg. urea per 100 cc., all the acid will be neutralized, and it will be necessary to repeat the determination, using only 1 cc. of blood. Fresh blood contains so little ammonia it may be disregarded. The figures obtained for urea-nitrogen may be converted into urea by dividing by the factor 0.467.

The amount of urea-nitrogen found in normal blood is 10 to 18 mg. per 100 cc.

The patient must take neither food nor water during the seventy-two minute period. If any urine be voided during the interval, it must

be added to that obtained at the end of the period. The urine must be carefully collected avoiding any loss and the total quantity accurately measured. The patient's weight should be taken on the day of the test.

The following data are now available: The quantity passed in seventy-two minutes, which may be multiplied by 20 to give the twenty-four-hour amount; the grams of urea per liter of urine, from which may be determined the amount in twenty-four hours; the grams of urea per liter of blood; and the patient's weight in kilograms. These figures may be substituted in the formula.

McLean has shown that these findings correspond very closely with those of the phenolsulphonephthalein test. While 100 is taken as representing normal, it is stated that usually the index is between 100 and 200, and variations between 80 and 300 are not infrequent in normal persons. He states that an index below 80 is to be considered abnormal, though not necessarily seriously so. In renal disease an index below 50 is indicative of a considerable degree of renal impairment of functional ability. It is believed by him that the amount of damage to the kidneys is increasingly greater as the index is lower and tends to approach zero.

(*i*) *Experimental Polyuria Test.*—This test was devised by Albarran, and consists essentially of taking specimens of urine from each kidney while the patient is thirsty, and after comparison of the two specimens, have the patient drink a large quantity of water, the effect upon kidney activity then being noted.

The basic factors of this test are: (1) The function of a diseased kidney is more uniform than that of a healthy one, and the more extensively its parenchyma is destroyed the less will its functional ability vary on different occasions. (2) If but one kidney is diseased, or if it is more diseased than the other, given a disturbance of urinary function, the more diseased organ will show less functional disturbance than the sound, or relatively sound one. Thus, when large quantities of water have been taken into the alimentary tract, a separate examination of the urine of each kidney will show that the sound or less diseased kidney is doing more work, and is excreting a larger total amount of fluid and solids, although the actual percentage of solids will be diminished; the function of the diseased kidney will, on the contrary, be but little or not at all affected.

Method.—The patient should abstain from food for four hours and from liquids for at least three hours. The urine is thereafter collected for one-half hour, and saved for comparison with the specimens taken after the ingestion of the fluid. At the end of the half hour 300 to 400 cc. of mineral water, about three ordinary glassfuls, are drunk by the patient and the urine is thereafter separately collected by voiding.

The total quantity of urine passed should be noted, the quantity and percentage of urea and sodium chloride noted, the freezing-point

obtained, and if phloridzin has been given the amount of sugar estimated.

Normally the polyuria appears within the first half hour, reaches its maximum during the third half hour and then rapidly declines. The total amount of solids remains constant or increases, but the percentage sinks in proportion to the polyuria. In impaired renal activity polyuria will be absent or delayed and the solid constant unaffected.

THE URINE IN DISEASE.

The diseases which produce distinctive urinary changes are:

1. **Renal Hyperemia.**—Active hyperemia is usually an early stage of acute nephritis. The urine is generally decreased in quantity, highly-colored, and strongly acid; albumin is always present. The sediment contains a few hyaline and finely granular casts and an occasional red blood cell. Passive hyperemia occurs most commonly in diseases of the heart and liver and in pregnancy. The quantity of urine is somewhat low and the color high, except in pregnancy.

2. **Nephritis.**—The urine in all cases of nephritis contains albumin and tube-casts, and when well-marked disease is present, shows a decrease of normal solids, especially of urea and the chlorides.

3. **Renal Tuberculosis.**—The urine is pale, usually cloudy, and the quantity may be increased. In early cases the reaction is faintly acid, but in advanced cases is alkaline, and the urine has an offensive odor and is irritating to the bladder. Pus is nearly always present but is intimately mixed with the urine and does not settle as quickly as the pus of cystitis. Tubercle bacilli are nearly always present, although animal inoculation may be necessary to detect them.

4. **Renal Calculus.**—The urine is usually somewhat concentrated, with high color and strongly acid reaction. Blood is frequently present, especially in the day time and after strenuous exercise. Crystals of the substance composing the calculus, uric acid, calcium oxalate, cystin, may often be found. The presence of a calculus generally produces pyelitis and variable amounts of pus will then appear.

5. **Pyelitis.**—In pyelitis the urine is slightly acid and contains a small or moderate amount of pus, together with many spindle and caudate cells. Pus casts may appear if the process extends up into the kidney tubules. Albumin is always present and in decidedly greater quantity than is found in cystitis, a point of much value in differential diagnosis.

6. **Cystitis.**—In acute and subacute cases the urine is acid and contains variable amounts of pus, with many epithelial cells from the bladder, chiefly pyoform, large round, and rounded squamous cells. In chronic cases the urine is generally alkaline. It is pale and cloudy from the presence of pus, which is abundant and settles readily into viscid sediment. Numerous bacteria are always present.

7. **Vesical Calculus, Tumors, and Tuberculosis.** —These conditions produce chronic cystitis with its characteristic urine. With neoplasms considerable hemorrhages are apt to occur. Particles of the tumor are sometimes passed in the urine. No diagnosis can be made from the presence of isolated tumor cells. In tuberculosis the tubercle bacillus can generally be detected.

8. **Diabetes Insipidus.** —In diabetes insipidus there is continued excretion of very large quantities of pale, watery urine, containing neither albumin nor sugar. The specific gravity varies between 1.001 and 1.005. The daily output of solids, especially urea, is increased.

9. **Diabetes Mellitus.** In diabetes mellitus the quantity of urine is very large. The color is generally pale, while the specific gravity is nearly always high —1.030 and 1.050, very rarely below 1.020. The presence of glucose is the essential feature of the disease. The amount of glucose is often very great, sometimes exceeding 6 per cent while the total elimination may exceed 500 grams in twenty-four hours. Acetone is generally present in advanced cases. Diacetic and oxybutyric acids may be detected and usually warrant an unfavorable prognosis. Accompanying the acidosis there is a corresponding increase in the amount of ammonia.

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CHAPTER IV.

CYSTOSCOPY AND ROENTGENOLOGICAL DIAGNOSIS.

DEVELOPMENT OF THE CYSTOSCOPE.

History.—The desire to inspect the cavities of the body is probably as old as the practice of medicine itself. It has already been mentioned in our attempt to trace the beginning of urological practice that a vaginal speculum was employed by the ancient Hebrews and the Roman physicians, and the latter also had some devices for making rectal examinations, some of these instruments having been recovered from the excavations of Pompeii. But the entrance to the bladder in both male and female is a way so "straight and narrow" that all attempts to make it a passage for instruments which would render its visual examination feasible failed up to the opening of the nineteenth century.

The history of cystoscopy naturally divides itself into two periods: (1) That during which indirect illumination was employed, the source of light being a candle, oil lamp or gas flame; (2) the period of direct illumination, in the beginning by the platinum loop, and later by the perfected incandescent lamp.

First Period.—In Berlin in 1806 there was published an account of a "Lichtleiter" designed and employed by one Bozzini, a physician of Frankfurt. The Medical Faculty of Vienna, then the final authority for Central Europe upon all such matters, considered this innovation and condemned it upon the ground that the light it conveyed into the dark recesses of the bladder was too feeble to be of any practical service. The apparatus consisted merely of tubes varying in size and length, through which light was reflected from a candle-flame by means of mirrors, and it is probable that very little illumination did reach the bladder, though it may have been of considerable assistance in the inspection of the urethra.

Though Bozzini's individual effort was abortive the idea did not wholly die out, for in 1824 John Fisher, of Boston, Massachusetts, produced an instrument which was designed for the same purpose toward which Bozzini had vainly struggled, actually embodying the principles upon which Desormeaux, thirty years later, was to produce a practical apparatus. The American's work, however, made no stir in the medical world even among his own countrymen, and a similar fate attended the attempt made by Segales of Strasburg, who showed what he termed a "urethro-cystic speculum" to the French Royal Academy of Sciences in 1826. Segales' instrument was very like

Bozzini's. There was a funnel which was really a conical mirror, and this could be separated from the endoscopic tube, while reflection was effected by another mirror which was concave and had a hole in the middle for the passage of the observation tube, the source of light being two candles.

The efforts of all these pioneers passed practically unnoticed, and were wholly forgotten until revived by Desormeaux in 1853. To this French surgeon has been given the title of "Father of Endoscopy," and while it may be in a measure misleading and likely to assign to him the credit for originality to which he is not entitled, the fact that his industry and untiring advocacy made the use of instruments for the inspection of the urethra and bladder practical and possible, should justly award him all honor for inaugurating a new era in urologic practice. Desormeaux's instrument was modified and improved a

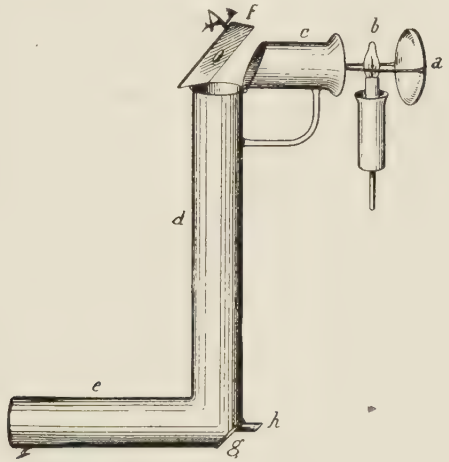

FIG. 2.—John Fisher's cystoscope (Boston, 1827).

dozen years later by Cruise of Dublin, and other improvements were added up to the year 1867 when a most notable advance was made by the substitution of the platinum loop as a means of illumination, thus introducing the forerunner of our present electric lighting system.

Second Period.— *The Platinum Loop.*—The genius who first conceived this plan was Julius Bruck of Breslau, a German dentist, who devised a means of inspecting the oral cavities of his patients by using a loop of platinum wire kept at white heat by means of a galvanic current. He had this instrument constructed and gave it the name of the stomatoscope, employing it with success on many occasions. He advocated its use in exploration of the bladder and rectum, but the instrument he designed especially to meet the needs of the urologist did not prove practical, and after a "try-out" in the Vienna Hospital, the idea was abandoned and Bruck's really remarkable invention soon forgotten.

But in giving the credit for producing the cystoscope to Max Nitze we should bear in mind the fact that his instrument was modeled upon the same principle as that of Bruck, and although he made the idea practical it cannot by rights be assigned to him as original.

Nitze's Design. - The incandescent loop of platinum used by Bruck was surrounded and kept cool by a water cylinder which was supplied by a continuous stream of water from a cistern suspended overhead which passed through a connecting pipe. The platinum wire was in connection with a storage battery the current from which maintained it at the point of incandescence. Appropriating this plan, Nitze proceeded to construct his electric cystoscope, and by the middle of the year 1876 a working model of it was actually used upon a living subject. Diecke, a Dresden instrument maker, the next year constructed a "urethroscope" after Nitze's design which was used by Dr. Oberländer of Dresden, but the idea had been by no means carried to full completion and the instrument maker found himself unable to cope with certain technical difficulties which arose when the full model was almost finished. For this reason Nitze was forced to carry his instrument to Vienna for completion, and there placed it in the hands of Joseph Leiter, whose superior mechanical skill was able to overcome the obstacles to practicability which the instrument had previously presented. This aid was very fully acknowledged by Nitze when he first demonstrated the instrument before the profession in 1879, and because of the prominence which was thus accorded the mechanician, the instrument was at first known as the Nitze-Leiter cystoscope.

As originally placed in Leiter's hands, it consisted primarily of a catheter tube which was bent at an angle. Upon the concave surface of this tube two triangular tubes were soldered which communicated with each other at the upper end beyond the angulation. Between these two triangular tubes a third was fastened in the same manner and into this third tube a fourth one was slipped, this last being insulated by a covering of silk so as to receive the wire which connected the platinum loop at the end of the instrument with the battery supplying the means of illumination. This platinum loop was protected by a section of quill. An observation window was located at the elbow of the catheter tube, and a telescopic tube had to be pushed down this until the window was reached, that is, perhaps five-sixths of the entire length of the instrument.

Disadvantages of the Apparatus. - There were many imperfections in this appliance. In the first place the water-cooling apparatus was very complicated; the cluster of five tubes formed a sharply-oval shape that was extremely undesirable; the quill did not serve its purpose of protecting the platinum loop from the water in the bladder, it was not transparent and was very likely to be scorched by the heat just at the point where it should have been most translucent; no means of closing the window was provided so that the telescope lenses were prone to be soiled by the water in the bladder which, of course, pre-

vented a clear view by the operator. Leiter simplified the water-cooling apparatus and increased the brilliancy of the light.

The Nitze-Leiter cystoscope put forward in 1879 was a great advance over its predecessor, for though it was very like it outside, the internal arrangement was much better. In form it resembled the calculus sound then in use, of catheter gauge 21-French, with an acutely-bent elbow and a rather long beak. Two forms were provided, one serving for the examination of the bladder neck and the anterior vesical wall and sides; the other being used for inspection of the posterior wall and base. The shape of both instruments was the same, the difference being merely in the arrangement of the window and lens and in the placing of the light. The platinum wire which was the source of light occupied the entire beak and around it was the water compartment, formed by the junction of two water canals which passed along the shaft. The aperture through which the light made its way was closed by a piece of rock crystal, and a screw-cap at the end of the beak permitted access to the platinum wire. The shaft was divided into four compartments, its length being a little more than 5 inches over all. The largest compartment was a central telescopic tube extending from the elbow window to the end where the eye was applied. This was provided with a system of lenses at both ends and the middle, so that the size of the reflected image could be increased through the window prism as in a microscope. Beside the two water canals was a fourth compartment, being a conduit for the wire connecting the platinum loop with its battery. The ocular end was equipped with funnel-tubes connecting the water supply, a most essential accessory for tempering the tremendous heat generated by the platinum loop. Here also was placed the attachment for controlling the current from the battery. Water was supplied from a tank elevated by means of a pulley to a height sufficient to maintain pressure to keep the cooling stream in continuous motion.

How inconvenient and cumbersome this apparatus was can be easily imagined. It was so complicated and so easily put out of order that the successful cystoscopist must needs be an excellent mechanician as well. The plunger which regulated the water-pressure had to be raised at short intervals; the battery had to be refilled and emptied before and after each examination, and we are feelingly informed that its "smell was often distressing." A rheostat governed the amount of current passing through the platinum loop, but even with this precaution it was often fused. In 1888 we learn from a letter written by K. Schall who was Leiter's British agent, to the London *Lancet* (refuting a recently made statement that Leiter's 1888 cystoscope was no improvement over the one put out nine years earlier) that:

"The Nitze-Leiter cystoscope of 1879 was very complicated. It was very cumbersome and required a porter for its conveyance. It required much technical knowledge. It was very delicate and required frequent repairing. I had, for a long time, to repair such an instrument

nearly every week, for the platinum loop which had to be very thin, fused very quickly. The instrument belonged to a specialist in Germany who persevered in its use."

The Incandescent Lamp.—The British Surgeons were not so persevering as their Teutonic confreres, nor as Roswell Park in this country, for while in Germany and the United States the alluring possibilities held out to the genito-urinary surgeon by this contrivance, far over-balancing its drawbacks, moved urological workers to make use of it, in England such an eminent surgeon as Sir Henry Thompson never even mentioned the possibility of employing the cystoscope, until many years after Nitze and Leiter had placed the result of their labors upon the market. It is somewhat surprising that though the incandescent lamp came into use about 1880, it was almost seven years before it occurred to anyone that it might be substituted for the platinum loop as a means of cystoscopic illumination for use in the male subject. And this is still more difficult to understand when we remember that it had been placed in specula designed for examining the rectum and in oto-laryngological instruments some time before this, and moreover, as far back as 1883, David Newman of Glasgow had employed an electrically-lighted endoscope for examination of the female bladder.

In 1887, however, two incandescent lamp cystoscopes appeared. One of these was designed by Nitze and made by Hartwig, a Berlin instrument maker, while the other was the production of Joseph Leiter, this time working independently. These two instruments though differing considerably in detail, were in principle much the same, and this principle survives in the cystoscopes used today, to all intents and purposes unaltered.

Modern Cystoscopes.—The present-day cystoscopes are of two distinct classes: (1) The fixed-lens pattern in which the lenses are inseparable from the shaft of the instrument so that the whole is permanently "assembled" as a single piece; (2) the two-part pattern, one part being the sheath and the other the telescope or ocular section. The devices of Nitze and of Leiter belong to the first type. The original of the second type is the instrument of Boisseau de Rocher[5] which he introduced to French medical men in 1889, though it did not come into general use in other European countries until some years later. An "indirect view," incandescent-lamp "megaloscope" had been designed by this same originator in 1885, so that his 1889 instrument was really an amplification and perfectioning of his earlier model.

Boisseau de Rocher's Instrument is therefore, the first composite cystoscope ever put into practical use, "the first and original attainment of double synchronous catheterization of the ureters (by two independent ureteral catheters at the same sitting); the first to afford free irrigation facilities through the cystoscope itself." This instrument consisted of a sheath which carried a removable incandescent lamp inside its beak by which the field was illuminated on the con-

vexity of the instrument; in the lower wall of this sheath were the two channels through which the ureteral catheters were to be passed, though these channels could also serve as outlets to change the fluid in the bladder if the operator so desired. This sheath was likewise furnished with an obturator which made the introduction of the instrument to the bladder more easy of accomplishment; this obturator being replaced after introduction of the instrument by the telescopic arrangement by means of which a direct view of the vesical interior was obtained. The originator's own description of the catheter arrangement which is the important and distinguishing feature of this type of cystoscope, is as follows:

"On the lower side of the straight sheath two tubes are placed, running parallel, their internal caliber being of the French scale No. 6. These tubes have their (upper) orifices directly behind the window, while at the lower extremity they are terminated by cocks and contain obturators to facilitate the passing of the instrument over the mucous membrane of the urethra. These small tubes are designed to serve two different purposes; their first utility is as conductors for the ureteral catheters. Nothing is more simple than, having seen the openings of the ureters, with the catheters in place, to guide these tubes (catheters) and engage them in the ureters. If one be pushed in from the outside it can be inserted to any depth desired. Finally, as these small catheters are under control and entirely independent, every facility is thus provided for catheterization of the two ureters without the necessity of withdrawing the (main) instrument, or even displacing the catheter first inserted.

"The second use, which is likewise of great importance, to which these two small tubes may be put, is the irrigation of the bladder. There is thus established in fact, a catheter of double current by means of which irrigation may be affected, which even if not rapid nor as complete as one would wish is at least capable of maintaining the fluid in a state of transparency."

The same year, 1889, which saw the presentation of this type of instrument, witnessed also an important modification of Leiter's direct view cystoscope, when Brenner added to it a small tube upon the shaft, originally designed as an irrigation channel but quickly utilized for the passage of the catheter. This modification was employed by Zuckerkandl and other German surgeons for catheterization of the ureters in the male, a feat hitherto deemed impossible. In our own country James Brown of Baltimore was the first to make use of Brenner's instrument, thus successfully accomplishing ureteral catheterization in the male subject.

Other Modifications.—Following this epoch, improvements in the mechanics of the cystoscope followed in rapid succession. Casper, Albarran and Nitze himself, quickly produced instruments which embodied the catheterizing features. The cold lamp invented in 1898 by Charles Preston of Rochester, New York, was introduced into what

was known as the Koch-Preston air cystoscope for inspection in the male subject; it was also used in the Valentine urethrascope. The next year Tilden Brown of New York modified the Brenner instrument by the addition of a second tube, so that it resembled the original Boisseau de Rocher model. An instrument applicable to both male and female was put forward by Bransford Lewis of St. Louis in 1900, which employed air as a means of vesical distention. The modification of the Nitze instrument suggested by Bierhoff in 1902 made the sheath and telescope separable so that the cystoscope could be withdrawn from the bladder while the catheters remained in place. The non-catheterizing instrument introduced by Schlagintweit in 1903 gave a retrospective view of the bladder neck and of the prostate which he accomplished by means of movable lenses. Luy's direct-vision cystoscope with air as the distending medium was introduced to the medical profession in 1904, and this model has since been several times modified.

Female Cystoscopes.—Work upon instruments applicable to female patients was begun, as has been already noted, some time before it was believed possible to apply such methods to male patients. Mention has already been made of the work of David Newman, the Scotch gynecologist, in applying the incandescent lamp to his work in cystoscopy. Three years later, in 1886, Pawlik in Germany accomplished cystoscopy and ureteral catheterization, placing his patients in the genu-pectoral position and using air-distention. He did not make use of platinum wire illumination in any form but depended upon an outside light. Pawlik's principles were greatly extended and his methods improved upon by Howard Kelly of Baltimore, whose work in this direction, first made known to the medical world in 1893, has continued to extend the scope and applicability of this instrument to gynecology from then up to the present time.

CYSTOSCOPIC MODELS NOW IN USE.

A consideration of the historical development of the mechanical devices by means of which visual examination of the bladder was made possible shows us that this may be accomplished by employing either of two types of instrument—the cystoscope or the endoscope. The essential difference between these two types consists in the equipment of the first with telescopic lenses, making the visualized image much larger than the diameter of the tube through which it is obtained; whereas the endoscope is simply a tube through which light can be transmitted in such a way as to permit direct unmagnified vision of the vesical cavity.

At present, instruments of the endoscopic type are not so popular as those equipped with lenses, though for certain purposes they offer advantages not available to those working with the more complicated instruments. The best known endoscopic tube is that of Kelly already

mentioned, which consists of a set of varying-sized tubes applicable to the female urethra. The patient is placed in the genu-pectoral position so that as soon as the instrument penetrates the urethra the bladder is distended by air. By means of a reflector illumination from without is cast up the tube so that the ureteral orifices can be located and catheters inserted directly without coming in contact with the vesical wall.

The chief disadvantages of this instrument are the high degree of proficiency on the part of the operator which it requires and the extremely fatiguing position which the patient must assume throughout the examination. It is, moreover, applicable only to females, and in many cases cannot be employed at all unless general anesthesia be used. Its advantages under certain conditions are however, so great, as to more than overbalance its drawbacks. When local applications must be made to the bladder the larger diameter of tube which can be employed makes this procedure very much easier; if the ureteral orifice must be cleansed before inserting the catheter, this can be readily accomplished; or when this precaution is not necessary, the catheter can be inserted directly into this orifice without coming in contact with a presumably infected bladder wall. In addition, the larger tubes give better access for the removal of foreign bodies, dilatation of the ureters, or other necessary minor operations; last, but by no means least in importance, is the ease with which the simply-constructed tubes can be adequately sterilized.

Elsner-Braasch Instrument.—An endoscopic tube which may be used for male patients has been devised by Elsner and more recently modified by Braasch of the Mayo Clinic, so that it is now known as the Elsner-Braasch instrument. Distention of the bladder may be by either air or fluid. The device consists of a sheath the beak of which carries a lamp. Two canals lie in the floor of this hollow tube which is inserted in the bladder with an obturator in place. When the instrument is in position the obturator is withdrawn and the lower end of the tube shut off by a glass window; after which air or water is introduced to distend the bladder. After the bladder is illuminated the ureteral openings are easily found by an experienced examiner, and the catheter can be passed through the canal provided for this purpose, for insertion into the ureter. The usefulness of this instrument is limited, its large caliber and very long beak being objectionable in many types of work, but it nevertheless gives to those treating male patients many of the advantages which the Kelly instrument provides for gynecologists, because of its large endoscopic tube.

McCarthy's Modification of the Luy's Endoscope.—The simple endoscopic tube employed by the French urologist, Luys, enabled him to catheterize the ureters in both males and females. A small magnifying lens, "easily movable from side to side in a transverse direction" is mounted at the upper end. The lens is so small that instruments can be introduced beside its margin. This type of instrument has given

satisfaction in French clinics for a number of years. McCarthy however, realized that a few modifications would greatly increase its practical usefulness. He employed the ordinary Chetwood tube of 26-caliber (French) with a smooth round bore for the sheath; the wire supplying current to the very tiny lamp is carried in its own tube the entire length of the instrument, making substitution of a fresh lamp when necessary, a very simple matter by merely withdrawing the lamp and wire through the tube. The lens attachment is improved by being placed about 1 inch away from the opening in the endoscopic tube, the circumference of the lens being also less than that of the endoscopic tube. This lens can be focused at will, or deflected if desired, being so adjusted as to easily permit applications or other procedures to be carried out upon the urethral mucosa, meanwhile maintaining a brilliant magnified picture. McCarthy also applied to this instrument the universal attachment which he had devised for his cystoscope.

McCarthy's endoscope is introduced with an obturator in place, but when it is in position the obturator is withdrawn and the light and lens-bearing attachment adjusted to the sheath by means of two grooves which fit over corresponding rods on the endoscopic tube. The advantage of this arrangement is that it provides absolute rigidity. The mucous surface being dried with cotton conveyed by a delicate wire applicator, the current is turned on, the resulting illumination enabling the operator to view the entire anterior urethral mucosa with absolute clearness, and by employment of the usual digital methods of traction, herniation and pressure below the tube, to bring into his range of vision all or any part of the mucous membrane for inspection or treatment.

The advantages which its modifier claims for this instrument are "simplicity of construction, ease of adjustment, absence of jarring, and a clear, clean-cut, magnified field maintained continuously throughout whatever operative steps may be deemed necessary by the operator."

The Kollmann-Wiehe Tubes.—Still another modification of the endoscopic principle is that of Kollmann and Wiehe, who introduced a screw at the outer extremity of the tube so that it may be expanded in much the same manner as one dilates the horn of a bagpipe. This is a very ingenious device, but it is a question whether the slight enlargement of the visual field which it accomplishes is of sufficient value to compensate for the additional complexity which it imposes upon the instrument.

Kollmann also adapted Oberländer's urethroscope so that it might be used for taking photographs of the urethra, and for the purpose of increasing the visual field devised, in collaboration with Wiehe, a movable optical apparatus which was introduced into the urethroscopic tube and attached to the shank of the lamp. What is usually known as the Kollmann cystoscope was put forward in 1900, being a modification of the instrument devised by Gueterbock (1895) and also

very similar to that bearing the name of Hurry Fenwick, the eminent English urologist. The Gueterbock instrument consists of a telescope which is entirely separate from its enclosing sheath, the sheath itself being practically a metal catheter with a curved beak. The tube is first introduced into the bladder and thereafter that part of the instrument which carries the lamp and lens in addition to the telescope, is placed within it, openings being provided in which the lens and lamp rest when in position. Previous to the introduction of the tube the bladder is washed out and then distended with water. The Kollmann cystoscope has three removable telescopes, for observation, irrigation and double catheterization.

American Cystoscopes.—Those catheterizing cystoscopes devised in Europe very generally, with the single exception of Brenner's, approach the ureteral orifice by the indirect method, those of Nitze, Albarran and Casper being good examples. In this country however, the Brenner type of instrument has found much greater favor, no matter whether air or water be used as a distending medium, so that most of the devices originating here have been of the Brenner type. Several ingenious American operators set about producing an instrument which would combine the advantages of all the different European types with none of their drawbacks. Thus in 1904, Bransford Lewis endeavored to evolve "a cystoscope that would embrace in a single instrument the several features demanded for effective and comprehensive cystoscopy, together with ureteral catheterization; embodying also the means for adequate irrigation and rapid exchange of fluids." The fruit of his labor is known to us as the Lewis Universal Cystoscope. Pursuing a similar ideal F. Tilden Brown of New York improved the Brenner instrument, first by separating the telescope from the sheath and placing it in channels for conveying the two catheters for simultaneous ureteral catheterization; and later, by cutting an additional window upon the concave aspect of the beak, as well as changing and modifying the position of the lamp.

The Buerger-Brown Cystoscope.—The sheath principle introduced into this country by Brown, has been adopted by Buerger in his catheterizing cystoscope, which is at present perhaps, the one most popular among American urologists. This instrument consists of four parts: the sheath, the obturator and two telescopes, one for observation and the other for catheterization. At the end of the sheath a tiny lamp is placed, behind which is a large window. The working aperture is completely closed by an obturator. The observation telescope, though of good size does not fill the sheath tube entirely, enough room being left for the passage of irrigating fluid beside it. The optical apparatus, the deflecting device, and the grooves for the reception of the catheters are all combined with the catheterizing telescope section. The catheters emerge at the observation end through two channels provided for this purpose, while at the opposite end they are fastened by means of clips. The fluid from the bladder is prevented from escaping at the

observation end by rubber tips which firmly occlude the catheter extremities.

For this instrument the designer bespeaks the following advantages: The employment of a catheter for washing the bladder is unnecessary, the sheath serving for this purpose; because of its small size, its round shape, the smoothness of the region of beak and window, the introduction of this instrument is very easy and injury to the deep urethra is avoided; synchronous ureteral catheterization with two No. 6 French catheters is possible, and the telescope and sheath may be removed, leaving the catheters in the ureters; irrigation of the bladder may be very rapidly effected through the sheath after the removal of the telescope, or more slowly through the faucets, even while catheterization is going on; friction between the two catheters is eliminated by keeping each one in its separate groove, an arrangement which also enables the operator to insert a new catheter at any time without removing the telescope; if the lens becomes soiled the telescope can be removed without disturbing the sheath, or another telescope may be inserted if desired.

The Lewis Universal Operating Cystoscope. The cystoscope designed by Bransford Lewis of St. Louis does not differ greatly from that just described. It consists of one sheath fenestrated on both convexity and concavity, and supplied with two telescopes. This single sheath enables the operator to obtain any view desired, permits of double catheterization by both direct and indirect methods, and gives room for the passage of all smaller standard instruments for urethral or intra-vesical operations, thus not requiring the provision of special instruments designed to fit the cystoscope alone.

McCarthy's Observation and Operating Cysto-urethroscope. -One of the newest types of operating cystoscope to be offered to the urologist is that which Joseph F. McCarthy demonstrated at the meeting of the American Urological Association in May, 1923. This instrument permits of direct ureteral catheterization without deflection and enables one to carry on intra-vesical and intra-urethral operative manipulations with rigid appliances, at the same time that it makes it possible for him to visualize the distal end of these instruments with as much precision as has heretofore been done with the deflecting type of prismatic cystoscopes.

The lamp is placed at the extreme end of the telescope, an objective system having been constructed on the end of a periscope which deflects the angle of the optical axis about 25 degrees. The objective system consists of a double-acting prism, having one surface at an angle of 20 degrees from the axis, and another surface at 5 degrees. Only the 5-degree surface is silvered; the other acting by total reflection. The sheath is straight, with the vesical end cut obliquely to permit better visualization. The sheaths are of varying caliber and type, one a single oval tube, the others consisting of two tubes (one large or main tube, to the upper wall of which a tunnelled sheath is soldered) the

upper and smaller tube carrying the telescopic apparatus. There are two terminal openings; the shorter tube admitting operative appliances; the longer being the carrier for telescope and lamp. The eye-

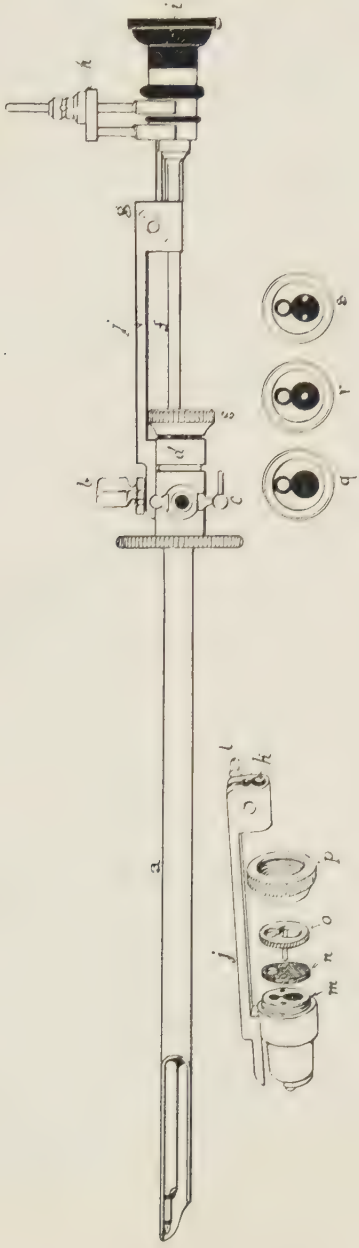

FIG. 3. — McCarthy's observation and operating cystourethroscope.

piece is far enough from the cystoscope proper to give a working space of about 5 cm.

Though entirely different from that of the indirect type, the manipulation of this instrument is extremely simple. The cystoscopic sheath is pointed just as one would train a gun, and—with the internal sphinc-

FIG. 4.—Blades inserted into sheath of McCarthy instrument for rendering manipulation of catheters and other instruments possible.

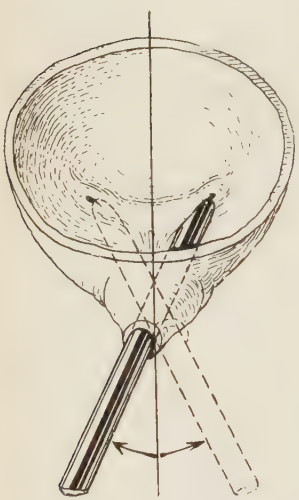

FIG. 5.—Visualization of ureteral orifices with McCarthy instruments.

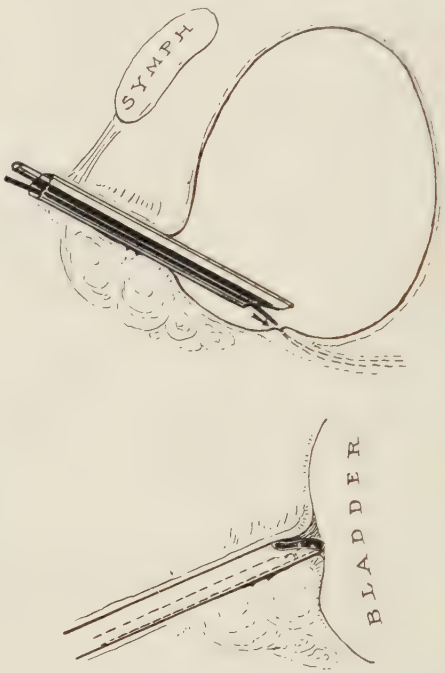

FIG. 6.—Upper figure shows catheterization of ureters. Lower figure shows visualization of vesical orifice.

ter as a fulcrum—the ocular end of the instrument is raised or lowered until a proper focus is obtained. The instrument can if need be, be placed directly over the ureteral meatus, so that catheter or forceps can be introduced. The sheath permits the introduction of such straight rigid instruments as forceps, scissors and bougies. In the

event of a burned-out lamp the telescope may be withdrawn with the ureteral catheter *in situ*, and be re-introduced over the catheter quite regardless of its size. The telescope is adjustable to different caliber sheaths of varying lengths.

This instrument is intended by its designer to serve as a direct observation instrument for the bladder, and as an operating instrument for urethra, trigone and ureters. It permits, in both male and female, the insertion of the wax-tipped catheter, and enables one to reach the diagnosis of stricture in the male as readily as it has heretofore been in the female. In the female this instrument will permit of the operative intra-ureteral and intra-vesical manipulations afforded by the Kelly type of female cystoscope, without placing the patient in the

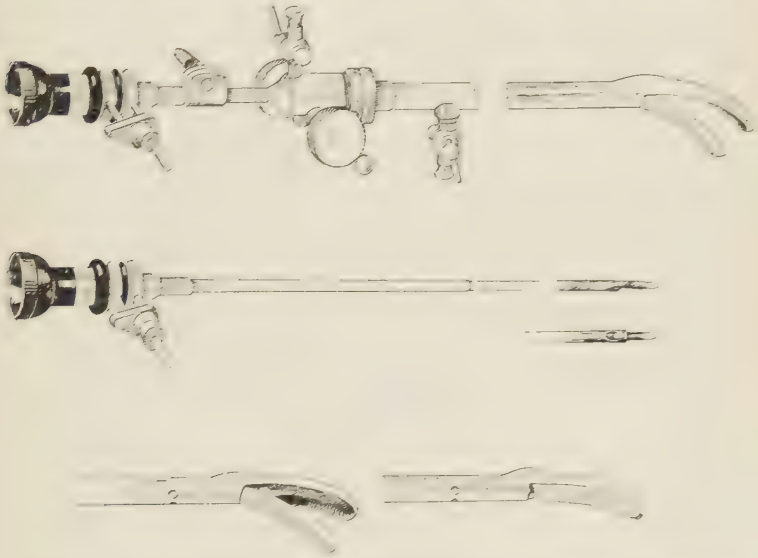

FIG. 7.—Lowsley cystoscopic rongeur (irrigating) for intravesical operations.

uncomfortable and fatiguing position which the Kelly instrument necessitates. As it permits of uniform dilatation of the ureter up to No. 18 (French) and does not require deflection of the instrument, it greatly simplifies intra-ureteral manipulations.

Irrigating Cystoscope for Operating Within the Urinary Bladder.—A modification of McCarthy's most recent instrument has been devised by one of us (O. S. L.) which is especially designed for the excision of tissue from the bladder wall for diagnostic purposes; for the removal of small stones intact, or the comminution of larger ones and removal of fragments; and for grasping and removing from the bladder catheters, bougies or any similar foreign bodies.

The sheath of this instrument consists of a hollow tube equipped at the distal end with grasping jaws, which curve from the shaft at an

angle of about 30 degrees. These grasping jaws are approximately 1.5 cm. wide by 2.5 cm. long, the upper and slightly smaller one fitting into the lower one as a punch. The steel at the angle of the lower jaw

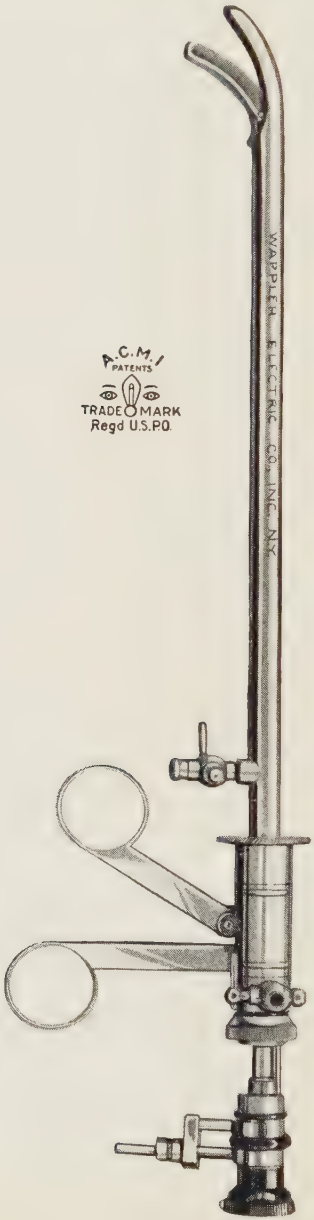

FIG. 8.—Lowsley instrument assembled.

is made especially thick in order to give it strength. The jaws are manipulated by a thumb-wheel fitting into a rachet at the proximal end, which in turn moves back and forth a rather heavy, straight bar, attached to the short arm of the lever of the upper jaw. The fulcrum of this lever is fixed by a pin upon the shaft of the instrument.

To provide for continuous irrigation a valve is placed at the top through which the irrigating fluid enters a conduit which discharges it into the bladder. The return flow passes into the jaws of the instrument through the sheath, finally flowing out through another valve.

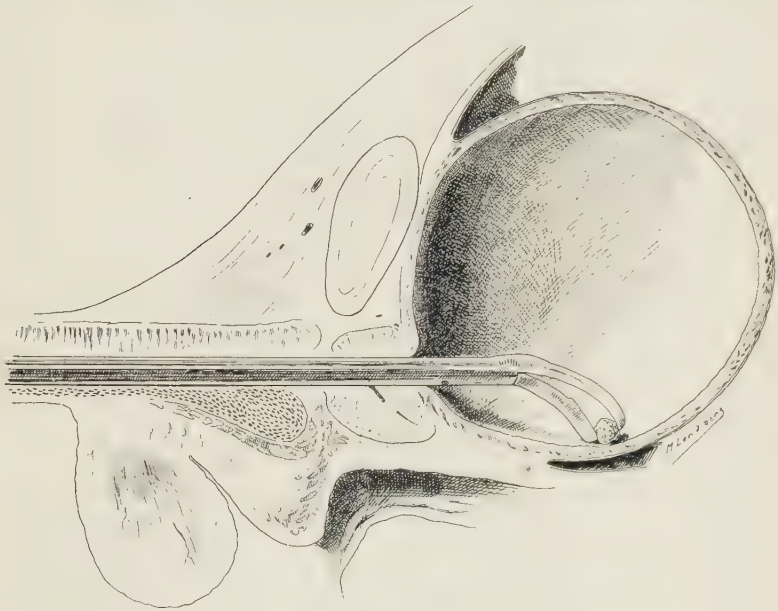

FIG. 9.—Instrument grasping stone in bladder.

The special features of this instrument are:

1. It is shaped like a sound, thus being easy to pass.

2. The jaws are large enough to grasp a sizable piece of tissue and strong enough to crush a stone. The upper jaw fits into the lower in such a manner as to act as a punch—not merely as an incisor. Foreign bodies may be grasped both at the proximal portion and at the tip of the jaws.

3. Perfect mobility is obtained by placing both lens-system and light-carrier within the sheath of the instrument.

4. Most important of all continuous irrigation may be carried on during the entire examination. The entrance of the fluid through the special conduit on top, and return through the main shaft promptly carries away any blood, keeping the field continuously clear and assuring uninterrupted vision.

5. The sheath may be sterilized by boiling.

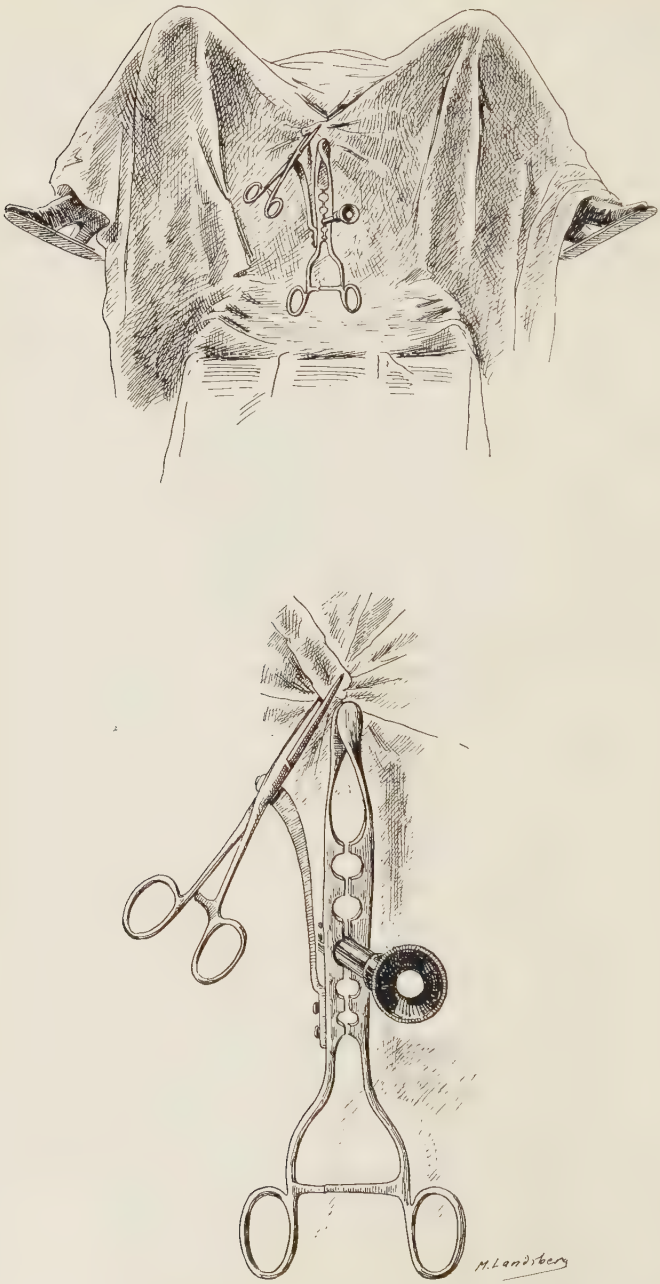

FIG. 10.—Lowsley cystoscope holder.

The mechanical details of this instrument were worked out by Mr. Reinhold Wappler.

Butterfield Baby Cystoscope.—This instrument is of use in the cystoscopic examination of children. It is size 15½ F. carries two No. 4 F. catheters and has an irrigating attachment. By its use one may catheterize both ureters of any baby of either sex. The authors have successfully used this instrument in the examination of a boy baby, aged nine months.

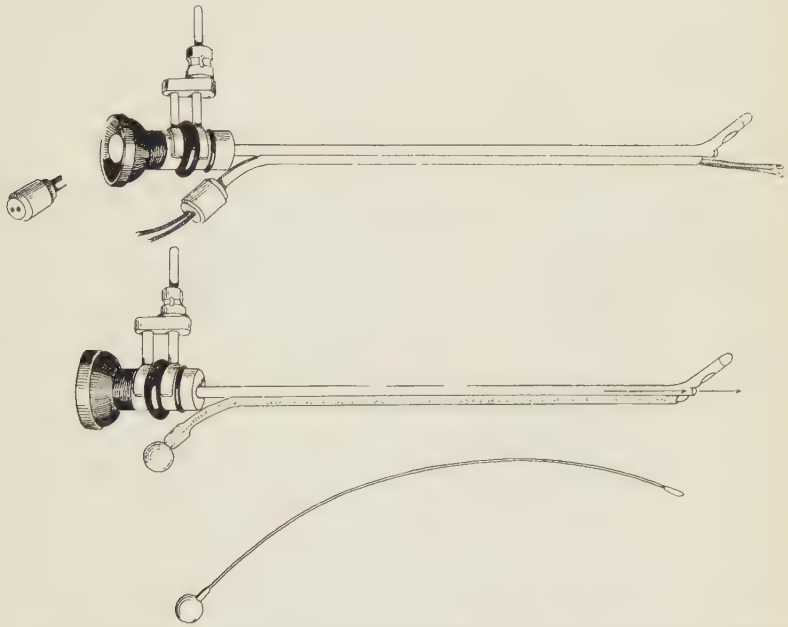

FIG. 11.—Butterfield's children's cystoscope capable of double catheterizing babies of either sex and any age.

TABLES FOR CYSTOSCOPIC WORK.

In no department of surgery is a specially designed operating table so absolutely essential as in urological work. Special urological tables have been designed from time to time, each succeeding pattern offering some improvement over those which have gone before. The employment of radiography in so many of the diagnostic procedures now used by the genito-urinary surgeon made necessary several important modifications in the design of examining and operating tables, one of the best of these improved types of apparatus being that which was described by Young in 1920, which is now finding extended employment both in private and hospital practice.

Young's Combined Cystoscopic and Roentgen-ray Table.—This table[41] provides a flat back plate capable of being moved through a large arc from an extremely depressed to an almost upright position. The leg

rests are easily movable and so strong that the patient may sit upon them when upright. The operating shoulder rests are mechanically movable, permitting the patient's position to be changed at will. A drainage pan is provided which remains in a horizontal position whatever the angle of the table proper, but is yet so located as in no way to interfere with the manipulation of roentgen-ray plates beneath the table top. There is in addition, an roentgen-ray attachment which gives great facility of movement and likewise affords a simplified mechanism for stereographs.

The designer of this table regards it as especially valuable in perineal prostatectomies upon very aged men, because these patients can be changed from the horizontal position in which they are anesthetized, to the perineal position by a very simple mechanical procedure. The leg-rests are elevated, the anesthetist turning the crank which operates the shoulder-rests, and the perineal elevator is operated automatically by the movements of the shoulder-rests, thus readily securing the perineal position with minimum disturbance to the patient.

Kretschmer Table.[21]—The Kretschmer table is especially designed to enable the examiner to carry out cystoscopy while the patient is in the prone position. Its construction was designed primarily for routine cystoscopic examinations, ureteral catheterization, various intra-vesical manipulations, such as fulguration or litholapaxy, as well as routine irrigation and postoperative dressings. Attention has been given to keeping the floor from being wet by the wash-water used in irrigation, often a cause of short-circuiting or other interference with the efficient employment of mechanical devices. An aluminum insert has been provided in the back rest, so that a plate-holder may be slipped underneath the patient without removing him from the table—of practical value when there are pyelograms to be made.

Lowsley Cystoscopic Table.—In the design of this table the aim has been to combine all the best features of previously-existing tables, and at the same time to lessen the cost of construction as much as possible. The frame is constructed of $1\frac{1}{4}$-inch steel tubing finished in aluminum bronze. It is placed high, the fulcrum being 40 inches from the floor. The legs are spread to give added firmness and strength, those at the foot of the table being fitted with rubber caps, and those at the head with 6-inch rubber-tired wheels. When the proximal legs are raised slightly the table may be easily wheeled about, but when the rubber caps rest upon the floor the table remains fixed in position.

The table top which is long enough to permit resting the head of even a very tall man upon it, is perfectly flat without a break in its surface, the material being monel metal which does not rust and is not affected by acids, etc. At the foot there is a split through which fluids can escape into a conical monel metal reservoir, which slides backward and forward, being fixed at any desired point by means of a thumbscrew. A control wheel near the front enables the operator to raise or lower the head end, thus placing the patient at any desired angle.

The patient's legs are supported by improved Bierhoff knee-rests fitting on square shafts with tops turned outward 30 degrees. These rests cannot rotate but can be moved back and forward as well as up and down, and by drawing a spring catch which fits into a series of holes drilled in the metal disk, they may be shifted from a position even with the top of the table to a very acute angle.

The standard roentgen-ray tubes or diaphragm may be readily attached to this table, and no plate-holder is necessary as the plate may be placed directly under the patient's body on the top, the flatness of which eliminates the possibility of breakage.

Many other tables have been devised for use by the cystoscopist. Notable among these are the ones devised by Savier, Bumpus and Hyams.

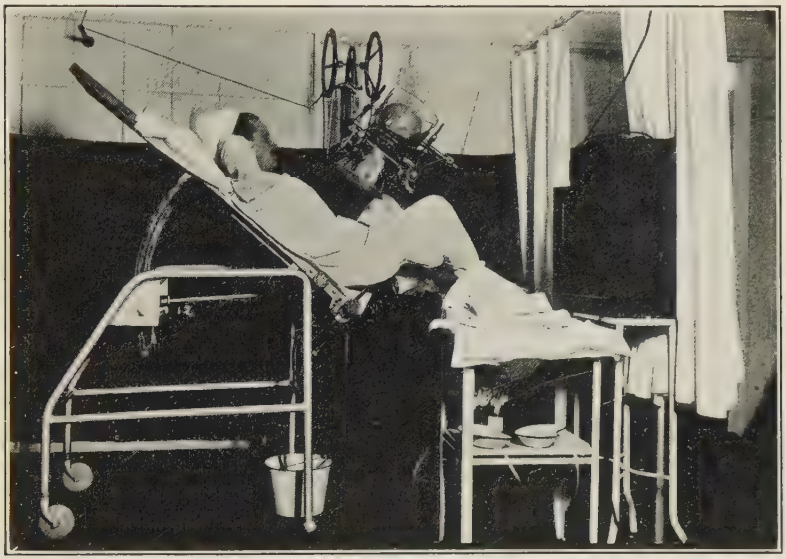

FIG. 12.—Lowsley cystoscopic table shown with patient elevated to sitting position with roentgen-ray apparatus properly located for taking view of entire upper urinary tracts.

The Potter-Bucky Diaphragm.—As roentgenology has now become so important a part of urological procedure, any discussion of tables for examination or operation would be incomplete unless mention were made of the mechanical devices which have recently been brought forward to facilitate roentgenological investigation of the urinary tract.

Chief among these is the application of the diaphragm originated by G. Bucky of Berlin in 1913 and made practical by Hollis E. Potter of Chicago, the results of whose labors became available to the roentgenologist about 1920. Since then the Potter-Bucky diaphragm

has become an absolute necessity for all those employing roentgenography in urological work, and should form a part of every table designed for urological examination. Bucky's original device was the placing between the plate or screen and the patient's body, of a grid formed from strips of metal so interlaced as to constitute a sort of

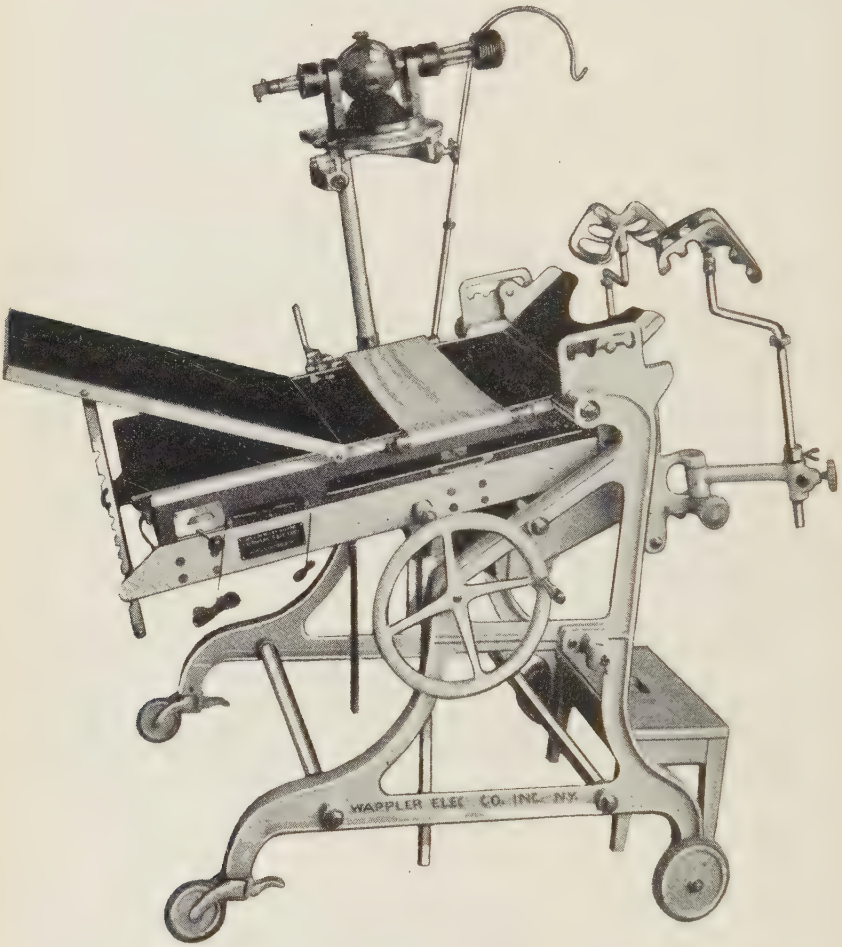

FIG. 13.—Squier cystoscopic table fitted with Potter-Bucky diaphragm.

"honeycomb," or many chambered screen. The walls of these numerous chambers were so arranged as to be parallel to the direction of the primary rays, thus offering no obstruction to their passage, while at the same time the secondary and scattered radiation which had heretofore always fogged the recording surface, was cut off by the absorbent metal of which the grid was composed. Motion is

imparted to the grid so that each part of it describes a circular path, the velocity being such that the walls of the grid do not cast a visible shadow on the plate or screen. This device, at first clumsy and unsatisfactory, producing a picture covered by lines running in both directions has, in Potter's hands, been so improved and perfected that it is now of the utmost practical value in all kinds of roentgen-ray work upon deep structures.

In the Pennsylvania Hospital at Philadelphia, the Potter-Bucky diaphragm has proved most efficient attached to a simple wooden table made by the house carpenter, while at the Cleveland (Ohio) Clinic, the top of the Young cystoscopic table was removed and the diaphragm built into the table, the whole being covered by a sheet of aluminum. It can be readily adapted to suit the needs of the individual examiner or those of a large clinic with many workers.

ROENTGENOLOGICAL DIAGNOSIS.

History.—The first roentgenological pictures made of the urinary tract were the work of James MacIntyre a Scotch surgeon who, "early in July, 1896" detected a renal calculus by this means. During the next four years British and American surgeons used the method with such success that at the opening of the present century Robert Abbé of New York[1] was able to collect 27 cases in which the diagnosis of renal calculi reached through their demonstration by radiography, had been confirmed at operation. But even before this, in 1897, Tuffier[39] had gone further, when he attempted to outline the course of the ureters by the insertion of an opaque catheter, and this idea was further advanced in 1904 by Klose[19] who was inspired to use an injection of bismuth suspension into the kidney pelvis, so as to render ureter and pelvis opaque to the penetrating rays. Klose did not succeed in making his idea practical, but this was accomplished two years later by Voelcker and von Lichtenberg in Germany, who successfully employed opaque injections of collargol, and were thus the real discoverers of pyelography. The advancement since made in this diagnostic method has been largely in the improvement of the opaque media employed. The toxic properties of collargol soon caused it to fall into disrepute and various other substances have been put forward from time to time; among them silver iodide solution[18] and thorium, and more recently, sodium bromide and sodium iodide.

Pneumoperitoneum.—The most recent addition to radiological diagnosis of the urinary tract has been the introduction of pneumoperitoneum. Though the idea of injecting air or gas into the peritoneal cavity to make visualization of the conditions there more possible was conceived early in this century, it was not until after the close of the World War that the method received any serious consideration. Two years ago a special method of gas injection for outlining the kidney was put forward by Carelli and Sordelli, two

Argentine urologists,[33] and their success was great enough to attract attention in Europe, especially in France. In Germany renal pneumoradiography has met with approval, if we may depend upon the reports of Rosenstein,[24] Boenninghaus,[4] and several others.

Value of Pneumoperitoneum.—Pneumoperitoneum is of especial value in cases where information is needed regarding the form, size, position, mobility and attachments of a kidney, or in establishing the kidney's presence or absence; when there is need to determine the origin and attachments of any palpated abdominal mass, or when any special conditions of the urinary tract are to be investigated. In its present stage of development at least, it should not by any means replace the older methods of diagnosis, but should be used only to supplement and confirm the findings of physical examination, cystoscopy and pyelography, no feature of the established routine of diagnosis being abolished in its favor.

Routine Roentgenology of the Urinary Tract.—In all cases it is proper to make a complete roentgenological examination of the entire genitourinary tract. Even if a patient brings with him roentgenograms obtained elsewhere, from which perhaps, a tentative diagnosis has been made by a general practitioner or another urologist, it is never safe to omit the complete examination. It may very well happen, for example, that though one calculus has already been located in the kidney, another may subsequently be demonstrated in the ureter, or others discovered elsewhere in the tract which have failed to show up in the first roentgen-ray plates.

It is also of great importance to determine the exact location of the liver margins, because pathological conditions in this organ have more than once led to a diagnosis of "floating kidney," and it is equally imperative that the exact outline of both kidneys should be made out, as only when we are in possession of this information are we in a position to judge intelligently concerning the probable source of the particular symptoms which are presented by the patient under examination.

Preparation of Patient.—When possible, the patient is prepared by thorough catharsis and enemas, castor oil being employed in preference to salines, as these last are likely to produce so much gas in the intestine as to render the kidney outlines unreliable. Frequently, however, it will be impossible to give preparative treatment, in which case we sometimes are obliged to make a second roentgen-ray examination, if shadows appear which may conceivably be due to the presence of enteroliths or other impactions in the intestine.

A rubber bag distended with air is employed to make deep compression, and by exposing two films, upon one of which the crest of the ilium appears just above the center, and in the other just below, we are able to get comprehensive views, first of the ureters and bladder, and second, of the ureters and kidney.

If no calculi are seen in either exposure we give a negative report so

far as visible stone formation is concerned, but it is always well to qualify any such statement, as there is a fair chance that calculi of very minute dimensions, or of a chemical composition not impervious to roentgen-rays, may be present without our being able to demonstrate them upon the films. But when the renal area has a shadow which we suspect to be due to the presence of calculus it becomes necessary to ascertain whether it is embedded in the cortical substance or is lodged in the pelvis, and this can often be accomplished only by the use of pyelography.

If we observe a shadow in either ureter we find it more satisfactory to verify such a finding by the use of an opaque ureteral catheter, further exposures being made at different angles so as to locate the shadow in its exact relation to the lumen of the ureter, which is defined by the catheter. Sometimes if a large calculus is lodged in the ureter, it may have become so much distended as to permit the passage of the catheter alongside the stone. This is the type of case which many urologists have failed to diagnose by the use of the wax-tipped catheter, for it is perfectly possible to introduce such an instrument and pass it the entire length of the ureter without it having come in contact with the calculus. It is, however, possible to make one or several ureterograms which will tell us just how large the lumen of the involved ureter has become, and frequently at what point it is constricted. If we see a shadow directly adjacent to the ureter in two or more exposures, we feel practically certain that a calculus is present, but in cases of doubt it is never wise to be economical in making exposures in different positions, the extra outlay of time and trouble being more than compensated by the increased accuracy of diagnosis.

Careful observation of the kidney outlines is always essential, and data should be gathered as to the position of these organs, together with their shape, whether normal or anomalous, their size, and the ease or difficulty with which they are visualized upon the roentgen-ray film. In some instances we have been able at this examination to detect lesions of the surrounding viscera, or of the spine, which were responsible for the symptoms which had been attributed to trouble in the urinary tract. But even when all findings are negative, it is well to make an endeavor to secure further roentgenological views, as frequently a second examination will demonstrate the cause of the symptoms as something wholly invisible under the conditions present at the first one.

PYELOGRAPHY.

Roentgenological examination of the urinary system after injection by some substance which renders the different organs opaque to the roentgen-rays, has now become a standard diagnostic procedure.

Pyelography, however, should be employed only in selected cases. Those suffering from acute or subacute infections of the kidneys, who

are emaciated or in a generally weakened condition, should not be subjected to this examination, as it may be regarded as a fairly rigorous procedure.

Pyelographic Media.—In our review of the history of urological roentgenology, the development of a suitable opaque medium was considered somewhat at length. We have personally made an extended study of this subject and found from animal experimentation that, aside from any toxicity of the medium employed, extreme pressure with over-distention of the kidney is a dangerous procedure merely from the mechanical effect alone.

Recent experiments have shown that the injection of solutions into the kidney under considerable pressure is followed by certain traumatic lesions, and it seems easily possible for these lesions to become the site for the lodgment of infection with subsequent penetration into the deeper structures of the kidney, or even to serve as nuclei for stone formation. It was reported that satisfactory filling of the kidney pelvis could be obtained by a slow injection at 50 mm. Hg. pressure, or less, and that the patient does not suffer so much pain and the mechanical damage to the kidney is less, when the pressure put on the kidney is low. The toxicity of the material used is also of great importance because the earliest students of this subject soon found that the kidney pelvis rapidly absorbed all the opaque substances employed. This aspect of the pyelographic media problem has also received a good deal of investigation. It was recently found[40] that the soluble media, sodium bromide, potassium and sodium iodide and thorium nitrate, are not retained in the kidney pelvis more than one and a half hours when the ureter is ligated, but are absorbed rapidly, apparently from the medullary portion of the kidney.

When administered intravenously, 25 per cent sodium iodide and sodium bromide produce no toxic effect, while potassium iodide and potassium bromide given intravenously are very toxic. Sodium bromide is more irritating to mucous membranes than either sodium iodide or thorium, as can be easily determined by placing a drop of the solution upon one's tongue. A 13.5 per cent solution of sodium iodide was found by Cameron to be as opaque as 3 molar 25 per cent sodium bromide, and definitely more opaque than the standard neutral thorium nitrate solution.

Kidney function, as determined by blood chemistry and phenolsulphonephthalein tests both in dog and man, is not changed by the introduction of molar and 4 to 3 molar solutions of sodium iodide into the kidney pelvis, even if the distention continues for twenty-five minutes. The same results were obtained with the 3 molar sodium bromide.

Sodium iodide has a lower viscosity than either sodium bromide or thorium; this low viscosity is a valuable factor, as it permits greater penetration. It is likewise the least hypertonic of the three media, and hence, the least harmful, as, other factors remaining constant, the

amount of injury which hypertonic solutions are capable of inflicting on living tissues is in direct proportion to their hypertonicity.

Sodium iodide was introduced into the urological department of the New York Hospital in January, 1920. Our clinical cases in which this medium has been used, confirm the observations of Cameron, who noticed no serious reaction after the use of sodium iodide. Though practically all patients upon whom a pyelogram is made suffer some discomfort due to the dilatation of the pelvis and ureter, this ordinarily lasts but a few minutes, though at times there are complaints of a persistent "ache" for a longer period.

Any elevation of temperature can practically always be ascribed to the dilatation of the irritated tissues, as it is believed that sodium iodide is *per se*, practically non-irritating. In our series of over 4500 pyelograms we have had very few cases where the temperature rose above 100° F.

Indications.—There is wide variation in the extent and virulence of renal pelvic infections, and it is quite impossible to tell exactly how much the pelvis has been damaged judging only from the appearance of the catheterized specimen from that side. In a case recently observed at the New York Hospital, at least one-third of the urine collected from the right side was composed of pus, which led to the conclusion that an acute infection of the right kidney must exist, although in the pyelogram the pelvis appeared to be only very slightly distorted. Upon exploration an inflammatory process was found in the ureter, which stopped abruptly just short of the kidney pelvis.

A greater or lesser degree of pelvic dilatation usually accompanies pyelitis, and the pelvic outline will show the delicate branching calyces so distorted that they have the appearance of having been "ironed" out, or smoothed off. Normally, these calyces should appear in the roentgenogram as flowers, the centers of which are formed by the papillæ. In pyonephrosis this distortion is still more marked, sometimes the entire inside of the kidney being hollowed out by the pathological process. Under conditions in which the urine from a catheterized kidney shows pus, the only possible way to determine the extent of the lesion is by the use of pyelography.

Stone.—Roentgenograms taken without the previous introduction of an opaque medium cannot be relied upon to reveal the existence of renal calculi, but even a large stone which does not cast a shadow in the radiogram will cause a thinning out of the pyelographic shadow. Even if a shadow can be seen in the kidney region, a pyelogram may be necessary to demonstrate its exact position in relation to the pelvis, and the use of this diagnostic means may be a valuable aid in determining whether or not operation is desirable or imperative.

Hydronephrosis.—Though hydronephrosis may be established by the steady and copious flow of urine through the catheter after the tip of the instrument has passed the obstruction which has caused the hydronephrosis, a much more definite and satisfactory diagnosis may be

reached by obtaining a pyelogram which shows the size and position of the enlarged kidney, together with the extent of the destruction and usually the lesion to which the pathological condition is due.

Neoplasms.—The earliest manifestation of malignant renal neoplasms is usually bleeding from the ureter of the affected side. A case of unilateral bleeding invariably calls for a pyelogram, because neoplastic growths always encroach upon the kidney pelvis very early in their development, and may easily be visualized by a distortion, or so-called "filling defect" of the pyelographic shadow. It is frequently possible for one experienced in the interpretation of pyelograms, to make a diagnosis when the tumors are very small, or even when there is as yet nothing more than malignant ulceration of the kidney pelvis. The advantages of such early diagnosis need not be emphasized to anyone familiar with the later stages of such neoplasms.

Anomalies.—Certain renal malformations, horseshoe kidney, unilateral kidney, infantile kidney, double kidney, and various other anomalies, can be easily demonstrated by pyelography, when all other means of diagnosis fail. Our method of pyelography also beautifully and positively demonstrates stricture of the ureter. While congenital stricture is most common at the ureteral orifice it may occur at any point in its extent. Stricture at the orifice causes the ureter to dilate and protrude into the bladder, the resulting ureterocele being plainly in evidence in the ureterogram.

We have seen 47 cases of double kidney pelvis, 3 being bilateral, and in all but 6 the ureters fused before entering the bladder, so that they presented only the normal number of ureteral orifices. Whenever there is an anomaly of the urinary apparatus we are likely to encounter some pathological lesion as well, as often the anomaly will be the site of an infection which has attacked a single section only, leaving the opposite portion in a normal condition.

Contraindications. Fever, or the existence of a subacute infection of the urinary tract is perhaps the most absolute one, because even a slight distention of inflamed surfaces will exacerbate the condition. Great deficiency of both kidneys makes the employment of pyelography very inexpedient, and even when there is but a slight degree of deficiency on both sides it is well to pyelograph one kidney at a time at separate sittings.

Technic.—The following is our method of procedure in doing a pyelogram.

The interior of the bladder is viewed with the cystoscope and any existing abnormalities are noted; lead catheters are then passed into the ureters, if possible, as far as the kidney pelvis, and specimens are collected which are sent to the laboratory to be examined bacteriologically (culture), chemically and microscopically. A phenolsulphonephthalein test is then performed to determine the efficiency of each kidney before the pyelogram is done. Two radiograms are taken pre-

vious to the injection of the opaque material, one of the kidneys and upper ureters, and another of the bladder and lower ureters.

If stone in the ureter is suspected a double exposure plate is taken after the method of Kretschmer, by following which a stone in the ureter will be seen in apposition to the lead catheter. After the first exposure is made the roentgen-ray tube is moved laterally, and if there is a stone *in* the ureter its shadow will move with that of the catheter, while if the shadow be cast by an object above or behind the ureter, it will not be in exact apposition to the catheter in the second picture, because of the changed angle of the roentgen-ray tube.

Twenty per cent sodium iodide is now carefully injected with a syringe especially designed for the purpose, until the patient reports a feeling of "fulness" in the back. Some of the solution is then allowed to run out and further radiographs are made, the last one being taken with the patient in the erect position, as was suggested by O. S. Fowler[16] in 1912, who made use of standing posture for radiographic diagnosis of intermittent hydronephrosis. The catheters are previously withdrawn to the ureteral orifices and sodium iodide injected during the withdrawal. Having the patient stand up has enabled us to bring out many strictures and other ureteral defects, which do not appear in exposures made when the patient lies prone with the ureteral catheters in their original position. The sodium iodide usually drains off when the catheters are re-inserted, thus promptly relieving the pressure induced by the injection. Before we employed sodium iodide as a medium we did not feel justified in doing more than one kidney at a sitting, but with our present technic the danger lessened. In bladder radiography both sodium bromide and sodium iodide are poorly tolerated by certain patients and in such cases silver iodide emulsion usually proves a satisfactory medium.

RENAL TUBERCULOSIS.

In every case in which renal tuberculosis is suspected a complete roentgenological examination is of the utmost importance. If the tubercular process is bilateral, the shadows will usually be so typical that any further examination will be superfluous, and the patient is thus spared the discomfort and additional strain of extensive clinical examination and cystoscopy. Again, the cystoscopic findings may not be typical of tuberculosis, or because of vesical contraction or impassable ureteral stricture satisfactory cystoscopy will be out of the question. Such a process as a closed tuberculous pyonephrosis usually gives no clinical symptoms suggestive of renal tuberculosis or indeed, any involvement of the urinary tract. In some cases in which the disease has progressed to complete destruction of the kidney terminating in caseation and deposition of calcium salts—the so-called "autonephrectomy"—the deposition of calcium salts will cast a shadow on

the roentgen-ray negative varying in density in proportion to the extent of the process.

It is in such cases as these, where for any reason a definite diagnosis cannot be made that the roentgenological findings will often be the determining factor in the recognition of the lesion.[11]

The shadows observed in the roentgenogram are cast by the calcium deposits occupying the area infected by tubercle bacilli, and if the investigator has had much experience with these conditions, he will usually be able to identify the characteristic outlines, notwithstanding the fact that they are capable of assuming a variety of forms. The shadows cast by the calcareous deposits of tuberculosis may be differentiated from those due to stone by the variation in density, the shadow in different areas being of irregular concentration; by a density which is less throughout than that usually cast by stone; and by the irregular and indefinite outline.[7]

At times, however, the shadow cast by the tuberculous calcification may so closely simulate that of a kidney calculus, that by relying upon the roentgenological evidence alone, no differential diagnosis would be possible. Conversely, almost everyone who has done much roentgenology upon the urinary tract can testify that on some occasions the shadows cast by stones are so dim and their outlines so hazy, that they can readily be taken for evidences of the existence of a tubercular process.

The lesions which cast shadows indicative of renal tuberculosis may be ranged into three general groups: (1) Small areas, multiple and generalized; (2) single areas of considerable size, or a few sharply localized, having a diameter of at least 1 cm., and often more; (3) large areas, which are diffuse and irregular, involving much of the kidney tissue, or even replacing it altogether.

Lime deposits are generally responsible for the first type of area, appearing as a faint irregular streak, or multiple and punctate, generalized throughout the kidney, most commonly at the poles in particular. Occasionally this type of formation appears singly.

When we have several isolated areas of concentrated calcareous deposit, the confusion with renal calculus is more likely to occur. The size of the shadow in no way indicates the extent of the tuberculous lesion. A shadow only a centimeter or two in diameter may represent a lesion which occupies the entire pole, or even all the kidney area.

The lesions of the third type cast large shadows varying in density, usually presenting regularly rounded outlines. If the calcium deposit is very thin, only a most minute examination of the plate will reveal any shadow at all.

When the kidney is completely caseated the appearance of the roentgenogram is truly remarkable. The shadow may appear as a complete outline of the kidney, the edge often showing tiny lobes placed at uneven intervals, and the entire shadow varying greatly in density at different portions of its surface.[32] In such cases a definite diagnosis

can be made immediately, even without the demonstration of tubercle bacilli. Where the kidney has been completely destroyed, the characteristic lobular appearance of the shadows, which are caused by the calcified caseous cavities is very definite, and never seen in any other type of kidney lesion.

Stereoscopic plates will usually permit the individual abscess cavities to be clearly distinguished one from another. The ureter becomes calcified only in very exceptional cases, but if the process has taken place it can be readily recognized, the ureter appearing upon the plate as a dense shadow as far as the calcified area extends.

The diagnosis of long-standing renal tuberculosis is easily established by roentgenology, but it is important to emphasize what has already been mentioned: The character of the shadows depends wholly upon the amount of calcification which has taken place, and as this varies in lesions of the same extent, the amount of damage already done to the kidney cannot always be accurately gauged by roentgenology alone.[12] But it is comparatively seldom that pyelography has to be used in such cases, and the added instrumentation is rarely justified, as the diagnosis can be confirmed from the detection of tubercle bacilli and pus in the urine, as well as the diminished kidney function. In these late cases, too, the introduction of a catheter is often impossible, because of ureteral obstruction.[3]

ROENTGENOLOGICAL EXAMINATION OF THE URETERS.

The value of ureterograms is greatly lessened because of "the splinting effect of the catheters which straightens out kinks and angulations, and otherwise disguises the pathological conditions."[6] Yet the shadow of the injected ureter shows us at just what angle it leaves the reservoir which it is its function to drain, a fact which can be positively established by no other means. Not infrequently, too, study of the ureterograms will show kinking and strictures of which the passing of the catheter gave no adequate evidence.[35] It is evident, then, that skilfully used, roentgenography of the ureter is a valuable diagnostic aid. Though it is not safe to consider urography negative for kinking of the ureter when it has been made with a stiff catheter passed into the pelvis of the kidney, if a portion of the injection fluid be withdrawn from the renal pelvis, and the catheter pulled down to the brim of the bony pelvis, the ureter may then be injected and any kinks demonstrated. Ureterograms for the demonstration of kinks should be taken with the kidney in complete downward excursion produced by a full inspiration, or by standing the patient upright. Ureterograms are made with less discomfort to the patient if the pelvis be emptied of fluid by suction before the catheter is drawn down into the ureter, which can then be injected without over-distention of the renal pelvis.[36]

For the location of stone in the ureter, the shadograph catheter has

proved its value, and if the method already mentioned[17] be employed, the diagnosis is usually very reliable. The greater part of the shadows of extra-ureteral origin which are commonly confused with those of ureteral calculi can be excluded by simply using the shadowgraph catheter without the double exposure, but occasionally ambiguity may be avoided by using this technic also.

It is important that the exposure be so arranged as to display the dilatation of the ureter if any such exist. If a stone lodges in the lower part inflammatory changes will usually cause dilatation below, while above it will be purely mechanical. A small spicula of bone attached to the pelvic brim, behind a dilated ureter, may be confused with a stone if the exposure be made so high that it does not show the lower portion of the dilated ureter.[14]

Ureteral stricture has been successfully demonstrated by a number of observers, notably Beclere and Henry in France,[3] who employed a sulphate of barium emulsion as a medium. They placed their patients on the left side, inclining the table at an angle of 45 degrees, and keeping its occupant in place by means of sand-bags. The rays were then so directed as to get almost a direct profile of the neck of the femur. In this way they obtained a perfect representation of the strictured ureter, and a continuous image of the entire length of the ureteral canal.

CYSTOGRAPHY.

Roentgenological examination of the bladder may be of great value in establishing the existence of vesical neoplasms, prostatic obstruction or diverticula, particularly if an obstruction of the urethra, excessive hematuria, contraction of the lumen, or intolerance on the part of the patient make the use of the cystoscope impossible. The existence of a neoplastic growth in the bladder is often indicated by the observation of a "filling defect" in the vesical outline, and by studying the extent and character of this defect information as to the size and nature of this lesion may often be obtained. It must be remembered, however, that partial distention of the bladder, reflex spasm or the presence of blood clots, may cause error in interpretation.[6]

Vesical examination in the lateral position, after filling the bladder with a 10 per cent solution of potassium iodide, has been recently practiced by two German roentgenologists[2] who call the method "cystoradioscopy." After placing the patient in the lateral position the central rays are aimed at a point two fingers-breadths in the ventral and cranial direction from the tip of the great trochanter. The continuation of the central rays will strike the center of the plate. The rubber catheter, through which the opaque medium was injected is left in position, so as to outline the course of the urethra. Using this method these investigators were able to make a number of anatomical and physiological observations upon both normal and pathological bladders.

An antero-posterior roentgenogram does not show the condition of either the anterior or posterior bladder wall. For this, a lateral exposure should always be made, the patient sitting on the plate with the upper part of the body bent slightly backward, while the center of the rays pass through the bladder in an axial direction from above downward. When this method is used, in many apparently normal cases, the bladder appeared, not as round or oval, but with pointed projections on the anterior wall. These projections were caused by a patent inguinal canal, and were not visible in plates taken antero-posteriorly.[29]

For the detection of diverticula the contrast cystogram is of value: After the bladder has been filled and a plain cystogram taken, the injected medium is drained off and the bladder immediately refilled with air by injection with a double cautery bulb through the urethral catheter and a second exposure made. The air-filled bladder now stands out in marked contrast to the pouches which have not had time nor opportunity to empty themselves of the opaque medium. Furthermore, the contrast method will usually give valuable evidence as to the number and relative size of the pouches. Occasionally, however, a diverticulum will be emptied too soon for the contrast cystogram to expose it. Therefore, absolute reliance cannot be placed on this method, but the findings must be carefully compared with those of the cystoscope.[17] As was not long ago pointed out[14] the opening into the bladder gives no indication of the size or seriousness of the cavity behind it, but by passing a radiograph catheter, a diverticulum may be visualized, and this may be still further demonstrated by a cystogram.

Joseph of Berlin has devised a light on the end of a bougie which transilluminates the diverticulum, giving a good idea of its size.

That diverticulum may be a factor in the production of vesical calculi has been recently suggested by urological workers in a large western clinic.[7] In the diagnosis of this condition, the use of the roentgen-ray is indispensable, for very often the roentgenograms will show shadows suggestive of stone which are not demonstrable on cystoscopic examination.

A roentgenogram should first be made of the vesical area, the bladder is completely emptied with a soft rubber catheter, and then filled comfortably full of the opaque cystographic medium. The catheter is withdrawn and the patient tipped into a semi-Trendelenburg position. Exposures are made at several different angles, so that if a diverticulum is present, in some of the plates at least, the shadow will not be projected upon the shadow of the filled bladder. The bladder is now emptied again, and another roentgenogram made which should show the outline of the diverticulum, the amount of retention in it, and whether or not shadows suggestive of stones are included in it. If there is doubt as to whether the shadows are in the ureter or in the diverticulum, the ureters can be excluded by the insertion of lead catheters, or the making of an additional ureterogram.

By carefully filling the bladder with a contrast medium and then

allowing it to empty, many phases of vesical physiology can be seen, which in sequence illustrates the whole complex of bladder movement. In this way atonic dilatations and ineffectual contractions may be observed, and in cases of inefficient ureteral openings, the urine may be seen to rise in the ureter.[32]

A method has been devised whereby the filling of bladder ureters and kidney pelves may be observed in a fluoroscopic screen reinforced by a screen composed of alternating strips of wood and metal.

Some of the pathological conditions which roentgenology of the bladder will reveal, lately noted in Germany,[20] are the existence of a bladder neck, which cannot normally be demonstrated, as only the internal sphincter effects the closure of the bladder against the urethra. In certain cases after a prostatectomy had been done, however, the internal sphincter had lost its function, and the roentgenogram showed a funnel-shaped extension of the bladder into the urethra. In spina bifida occulta, in the presence of inflammatory and carcinomatous infiltration of the bladder wall, or diverticula about the ureteral orifices, after the bladder has been filled with a contrast medium, a section of the ureter, and even of the renal pelvis has been seen to emerge, though normally, the ureters are invisible.[2]

Phleboliths may be differentiated from stones, especially those in the ureter, by their spherical shadows which are sharply outlined. In establishing such a diagnosis the shadowgraph catheter may help, but it is wise to change the direction of the rays and make another exposure, or to take a stereoscopic view.

Injection of Air.—The injection of air has been very successfully used for the roentgenological diagnosis of bladder tumors.[29] This method can be used when a cystoscopic examination is impracticable on account of the field being partly obscured by blood, and is less painful, and often less objectionable to the patient than cystoscopic examination.

Anterior and posterior roentgen-ray exposures should be made before injecting the air, to give information of the condition independent of inflation, and the relation of any gas or air which may be present in the pelvic colon or rectum. Vesical calculus if present is usually visible in these preliminary pictures. After cleansing the urethral orifice as for ordinary catheterization, as large a catheter as can be passed without pain or inconvenience to the patient is inserted, having previously been connected with the atomizer bulb by means of glass-tubing. All the apparatus must be carefully sterilized, and an extra precaution against infection taken by inserting a plug of sterile cotton in the glass tube, to act as a partial air filter.

Residual urine must be removed from the bladder, compression usually being necessary to eliminate as nearly as possible all fluid from the bladder. Air is then injected or compressed into the bladder until the patient complains of distress. Care must be exercised not to overdistent the bladder, for it would be perfectly possible to rupture a dis-

eased viscus, but if the injection is made slowly and the patient's complaints heeded, there should be no danger.

When the bladder is sufficiently distended one or more plates should be made posteriorly; after which the patient is turned on the abdomen and further plates made anteriorly, directing the rays through the bladder obliquely from below upward, so as to avoid the pubic arch as much as possible. When changing the patient's position, one must avoid disturbing the catheter, as the air should be allowed to escape through it as soon as the examination is finished, compression sometimes being necessary, in addition, in order to expel all the air.

The chief value of bladder roentgenology is outlining the number, size and position of diverticula, but in any case where the use of the cystoscope is difficult or impossible, it may serve a very useful purpose, and at all times, in conjunction with cystoscopy, it greatly facilitates prompt and accurate diagnosis.

PNEUMOPERITONEUM.

This method of diagnosis is as yet somewhat of an innovation, and for this reason is not generally used as a routine, but only in some cases where diagnosis is especially difficult, or the more common methods cannot be applied. For example, there are times when it is impossible to determine whether the patient possesses more than one kidney, and the only way of clearly demonstrating the renal outline will be with the aid of pneumoperitoneum. Tuberculosis of the kidney has sometimes been shown by this method, when all other means have failed, and the same is true of cystic kidney. In supplying information concerning new growths and retroperitoneal masses it has also proved extremely valuable. Definite palpable masses may be made apparent to the sight, their exact origin clearly indicated and the extent to which they are involving the surrounding structures made evident.[28]

The usual method of inducing pneumoperitoneum requires a very simple apparatus; the only accessories required are a lumbar puncture needle and a rubber tube, with the addition of the oxygen tank, if oxygen is employed instead of air. It is no longer considered necessary to sterilize the inflating medium, whether gas or air, but the needle and tube must, of course, be rendered thoroughly aseptic, and the site of puncture cleansed and disinfected, for which purpose iodine will be found most satisfactory. The bowels and bladder are previously evacuated, and some surgeons give $\frac{1}{6}$ grain of morphine by hypodermic one-half hour before the inflation is undertaken.

The needle is usually inserted somewhat below the umbilicus, in the median line, pushing it slowly as far as the fascia, whence a very slight pressure is ordinarily sufficient to penetrate the fascia and peritoneum, so that the point of the needle enters the abdominal cavity. By inserting the needle at a slightly oblique angle, its point may be kept close to the parietal peritoneum, which makes the inflation easier. The

rubber tube is now connected, and the gas or air allowed to enter the abdominal cavity, the amount being gauged by the existing conditions. It seems hardly necessary to add that the administration of pneumoperitoneum should be limited only to those of extended surgical experience, and is always to be regarded as on a par with a major surgical intervention.[34]

Usually the patient is inflated under the fluoroscope while in the dorsal position. When sufficient inflation is obtained the needle is withdrawn, he is placed in the lateral position, and each side examined in turn. He may then be placed in the "retroperitoneal position" and finally in the dorsal and ventral positions, using the horizontal fluoroscope. The advantages of using the retroperitoneal position are well illustrated by a case reported not long ago during the discussion of a symposium on pneumoperitoneum. There was a hard well-defined mass in the right lower abdominal quadrant, the origin of which could not be determined by physical examination. The employment of pneumoperitoneum showed a clear outline of the mass, and demonstrated that it was in no way connected with the kidney. The ureter and kidney pelvis were then injected to determine if possible, whether the mass were retroperitoneal. The ureter now showed in smooth outline, and upward and inward pressure upon the mass permitted a kink in the ureter to be demonstrated, which seemed to indicate that the ureter ran over the mass, which must, therefore be retroperitoneal. At the same time it was noted that the third and fourth lumbar vertebræ had a carious appearance, which naturally suggested the possibility of tuberculous abscess. Placed in the retroperitoneal position, chest and thighs supported by two blocks and abdomen hanging loosely between, an exposure from side to side gave a view of the retroperitoneal and prevertebral space. The mass then proved to be a psoas abscess.

By the employment of this position the presence and origin of a sarcoma of the kidney has been successfully demonstrated; it has also served to reveal a retroperitoneal carcinoma secondary to carcinoma of the prostate which was closely associated with the kidney, a perinephritic abscess, and one arising in the seminal vesicle, and a retroperitoneal carcinoma secondary to carcinoma of the bladder.[37]

When the abdomen is distended most patients experience marked pain in the shoulders, though in some cases this does not occur until some time after the inflation is done. Therefore, the method cannot be called a strictly painless one, but the advantages it offers when other diagnostic means have proved inadequate, are far too great to permit it to be discarded because of this drawback. In the hands of cautious and skilled operators of broad surgical experience, and conducted under the same precautions as are observed in any major intervention, there should be no hesitation in using it when necessity arises and there are no definite contraindications.

The greatest value of pneumoperitoneum to the urologist probably

lies in its employment in conjunction with pyelography. With the ureters and kidney pelvis as well as the kidney itself rendered opaque to the roentgen rays, the renal pelves and calices will be accurately outlined, and the renal structure, its enlargements and deformities shown in great detail.

The gas or air will be absorbed in the abdominal cavity in from one to seven days, but it is customary in many clinics to deflate the patient by reinserting the needle and letting as much as possible, escape in the same way that it entered. Some operators, however, object to this practice, and believe the gradual absorption of the injected medium to be preferable.

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PART III.

DISEASES OF THE GENITO-URINARY ORGANS.

CHAPTER V.

PENIS AND PREPUCE.

EMBRYOLOGY OF THE PENIS.

During the early part of intra-uterine life the development of the external genitals proceeds in the same manner in the embryos of either sex, so that for the first nine weeks they are in what is termed the *indifferent stage*. From about the fifth to the ninth week what is known as the *genital tubercle* gradually develops, beginning with a thickening of the mesenchyme external to the cloaca, and upon this a knob-like structure—the *phallus*—makes its appearance, and still later the *genital swellings* arise about the base of the phallus, being more definite in form at the sides. On the surface of the phallus nearest to the anus, the wall of the urogenital sinus opens through to the exterior, so that the primitive *urogenital opening* comes into existence. When the embryo has reached a length of 21 or more mm., the glans will be observed to be marked off from the base at the end of the phallus by a circular groove, designated as the *coronary sulcus*.

From this point, the tubercle in the male embryo rapidly enlarges and elongates to form the penis, and during this process the glans and primitive urogenital opening are removed for a considerable distance away from the anus. The *glans penis* is formed by the gradual downward growth of a sort of collar of epithelium, which remains somewhat incomplete on the side most nearly approaching the anus. The *prepuce* or *foreskin* is formed about the sphere of the glans, by the disappearance of the cells composing the center of the epithelial down-growth, and at the point where this down-growth fails, connection still remains between the glans and the foreskin, thus establishing the *frenum*, persisting in the fully developed male fetus as a tough fibrous band. Paired mesenchymal columns now come into existence forming the *corpora cavernosa penis*, and the adherence of like unpaired anlages, in the glans and in the shaft, gives rise to the *corpus cavernosum*

urethræ. As the phallus lengthens, the upper part of the urogenital sinus, from which the external genitalia of both sexes originates, likewise grows longer and eventually becomes the major portion of the *penile urethra*. The rest of this urethra is formed by closure of the primitive urogenital opening, which takes place when the fetus has reached an approximate length of 70 mm. When the fetus has attained a length of 100 mm., the solid urethral plate of the glans opens out to form a groove at the tip of the glans, this groove later closing in its turn, so that the urethra eventually reaches a definite point of opening at the tip of the glans.

DEVELOPMENT OF THE PREPUCE.

It was observed by Hart[33] in a two and a half months' old fetus that the glans has no prepuce but is covered with a thick epidermal layer. At the glans root the epidermis dips down solidly and then grows forward over the glans, the fold becoming inverted, so that what was superficial is now deep, facing the glans surface. The glans and the developing fold are blended and continuous as a tissue, and the area which will later become the preputial space is filled with epidermal cells, those in the center corresponding to the superficial epidermal layers. Thus the glans, at this stage of development is not free from the prepuce, but joined to it by unbroken ranks of epidermal cells.

The later separation of glans and prepuce Hart explains as probably due to the power possessed by the epidermis of desquamating at its free surface. Some of the cells in the center of the epidermal layer join themselves to the inner surface of the prepuce, while others become attached to the outer surface of the glans, so that the prepuce finally becomes fully movable upon the glans, as it is normally found in the later stages of fetal development, or in the new-born.

"We thus get the explanation of the power of the epidermis in forming lumina or bringing about mobility in opposed surfaces formed by its solid indipping, as it is evident that when epidermis dips in or grows into the mesoblast so as to form a solid infolding, the superficial epidermal cells thus become central, and their ultimate desquamation will make lumina or movable folds, as the case may be. The deep epidermal layer is evidently the active one in the indipping, as it stains deeply and has a larger nucleus than the more superficial cells. It follows from this that the so-called adherent prepuce found in young children, is really due to deficient breaking down of the preputial epidermic plug, and not to pathological adhesions."

ANATOMICAL STRUCTURE OF THE PENIS.

When it has reached its full development in the adult, the penis is ordinarily about 3 inches long in the flaccid state, and almost double that length when erected. Three elastic bodies having somewhat the

appearance of rods, separated one from another by envelopes of strong resistant fibrous tissue, make up its main portion. Fully two-thirds of the organ is composed of the *corpora cavernosa*, which lie side by side in its dorsal portion, and in the angle formed by their apposition is found the smaller, *corpus spongiosum*, which has been aptly described as bearing to the two corpora cavernosa the same relation that a ramrod does to the double barrel of a gun. The corpora cavernosa are but slightly separated in front, their extremities being blunt and cone-shaped, but behind they are separated widely beginning at the crura of the penis. Elsewhere they lie closely united.

The corpus spongiosum is composed of erectile tissue, and like its neighbors is surrounded by a tough fibrous sheath—the *tunica albuginea*. Through the sponge-like tissue of this body passes the urethra, and the whole structure is subdivided into *bulb*, *body* and *glans*. The bulb lies in the angle formed by the crura of the corpora cavernosa at the point where they come together, being attached to the lower surface of the *triangular ligament*. The body is the posterior expanded portion of the perineum proper and surrounded by the *accelerator urinæ muscles*. The *glans penis* is an expansion of the distal end of the corpus spongiosum which spreads over the dorsal surface of the body, forming a conical cap. Its border is well-defined and somewhat elevated, and is designated as the *corona glandis*, projecting dorsally and laterally beyond the extremities of the corpora cavernosa. Behind this is located a depression usually termed the *neck of the penis*, *cervix* or *coronary sulcus*. The glans, as well as the corpus spongiosum proper, is pierced by the urethra, which finds an outlet in the *meatus urinarius* or external urethral orifice, a vertical linear opening, at the summit of the glans.

The structure of the integuments which enclose the various bodies making up the penile organ, is of importance to an understanding of the pathological conditions to which this part of the body is subject. Beside the sheath of fibrous tissue already mentioned as enclosing the corpora cavernosa and corpus spongiosum, there is another sheath, external to these, which binds all the structures together; this is known as *Buck's fascia* or *fascia penis*. The two rounded extremities of the corpora cavernosa are completely invested by this covering which has a firm attachment to the base of the glans, and at the angle of the penis is continuous with the suspensory ligament above and the deep layer of superficial fascia below. A loose layer of fatless areolar tissue lies above this, which contains a delicate layer of unstriped muscle fibers, and is known as the *dartos*. It extends between the two layers of skin which form the *prepuce*, and the muscle fibers of which it consists compose the *sphincter of the prepuce*.[21]

Normally, the delicate, freely movable skin which forms the outer covering of the penis extends forward far enough to almost completely cover the glans. Thence, it is folded back upon itself, having an attachment at the coronary sulcus, and passes forward over the glans until

it reaches the meatal mucous membrane. This double fold of skin is the *prepuce* or *foreskin*. A small median fold passes from the prepuce to the under side of the glans, forming a tough fibrous band which is called the *frenum*, and at the preputial orifice the subcutaneous layer is more highly developed than at any other point, though the inner surface of the prepuce as well as the covering of the glans, are delicate in structure, moist, and closely resembling mucous membrane. Sometimes minute sebaceous glands (glandulæ præputiales) are found in variable numbers on the glans and the inner surface of the prepuce; the secretion from these, when they are present, may help to form the *smegma præputii*, which tends to collect in the groove between the glans and prepuce. The main source of the smegma is to be found in the desquamated and broken-down epithelial cells derived from the surface of the glans and prepuce.[19]

Suspensory Ligament. The suspensory ligament is an elastic band of fibes, triangular in shape, attached to the front of the symphysis pubis at the lower part of the linea alba, and likewise to the corpora cavernosæ at their angle of junction. It extends to the fibrous capsule of the penis just anterior to the location of the pubic bones where it blends with this fascial sheath.

Muscles.—Physiologically, the muscles of the penis are of extreme importance. Chief among them is the *ischiocavernosus* or *erector penis*, the chief function of which is to exercise pressure upon the veins, thus increasing turgescence. It has its origin at the ischiatic tuberosity, and its insertion in the lower part of the fascia covering the corpora cavernosa. The *bulbocavernosus* or *accelerator urinæ* takes its origin from a central position in the perineum, and extends upward and forward, so as to surround the bulb and the posterior portion of the corpus spongiosum, having as its function the complete evacuation of the urine as it is expelled by contracting the termination of the urethra, as well as the application of force to the ejected semen, as its stream passes from the posterior urethra. Beside these chief muscles there are also unstriped muscle fibers in the erectile tissue and the urethra.

Bloodvessels and Nerves.—The blood supply of the penis is very abundant, which becomes an important consideration when operation is to be done upon that organ, or if it has been subjected to injury so severe as to make the possibility of its preservation uncertain, as it is capable of regeneration even under most unfavorable conditions. This is due in great measure also, to the highly intricate innervation of the tissues. The blood supply of the accelerator urinæ, erector penis and transverse perineal muscles is derived from the superficial and transverse perineal arteries, and their innervation from the muscular branches of the perineal nerve. The two dorsal arteries pass forward on each side of the dorsal vein, through the suspensory ligament, giving off branches to the corpora cavernosa and corpus spongiosum, and finally reaching the glans and prepuce. The erectile tissue of the

corpora cavernosa and corpus spongiosum is supplied with blood by the arteries derived from the internal pudic, as is also the artery of the bulb, which provides the blood supply of the corpus spongiosum. Anastomosis of these vessels with branches of the external pudic also furnishes a collateral circulation.

The largest vein in the penis is the dorsal vein which, in common with the smaller veins in this organ, empties into the prostatic plexus, passing through the suspensory ligament through a groove in the dorsum.

Lymphatics.—A knowledge of the lymphatic connections of the penis is most important to the surgeon who has to deal with malignant disease in this location, as metastasis is of very frequent occurrence, taking place along the line of the lymph channels. The lymphatics of the penis, in common with those of the scrotum, thigh and lower section of the abdomen, are part of one system draining the lymph nodes of Scarpa's triangle and the inguinal area. The most deeply situated of these glands are three which lie at the point of union of the external saphenous and femoral veins, and in the crural canal. These deep glands receive vessels from the nodes lying higher up, as well as lymphatics from the glans penis. It is important to keep in mind the deep group of inguinal glands as possible receptacles for metastasis in cancer of the penis, for from this group the glands of the pelvis may become involved.[20] The lymphatics of the penis may be divided into three groups: (1) Those of its superficial covering, draining into the superficial inguinal nodes, which in turn anastomose with the deep inguinal nodes; (2) those of the glans penis, which drain into the deep inguinal nodes and in turn, anastomose with the external iliac group in the pelvis; (3) the lymphatics of the urethra which drain into the deep inguinal nodes with the lymphatics of the glans penis and another system, which passes over the symphysis pubis and directly into the nodes in the external iliac group.

ANOMALIES OF THE PENIS.

Contrasted with anomalies of other organs with which the genito-urinary surgeon has especially to deal, abnormalities of the penis are very infrequently seen. A comparison of the sections in recently issued text-books which are devoted to this subject will show that the material is practically identical, and that most of the illustrative cases were first published a long time ago. It is not unreasonable to suppose that such malformations occur much more frequently than the paucity of literature on the subject would lead us to believe. There are several reasons for this, chief among them being that abnormalities in this organ are usually associated with marked malformations in other parts of the body, generally incompatible with life, or are found in those of deficient mentality. Should the subject of such a misfortune reach manhood, he will be likely to do everything in his power to

conceal the unusual structure of his external genitalia, and the anomaly will only be observed when he is forced to undergo examination for some unrelated condition. Thus but few descriptions of such cases find their way into literature.

Double Penis. –Two recent examples of this anomaly are the cases of McLennan[46] and Vaudescal.[75] In the first there was a complete hypospadias involving both sides and "a redundant mass of mucous membrane situated at the side of the urinary outlet" which appeared to be of rectal origin. This was removed immediately after birth. In Vaudescal's patient, who was three months old at the time he was exhibited, there was balanic hypospadias of the normally located penis, though the prepuce was complete. The right supernumerary penis, which was about 2 cm. to the right of the first one, was normal in appearance and presented no hypospadias, but as no urine passed from it the urethral canal was explored by a sound, and was found to end in a blind pouch a few millimeters from the meatus. Each penis had an accompanying scrotum, but that of the median penis had but a single sac at the left in which an apparently normal testicle could be palpated. There was no left sac, although the median raphé was plainly visible. The supernumerary scrotal sac was only partially developed and contained no evidence of testicles. Radiographs taken after an opaque enema showed that the internal organs and the bones were in no way abnormal.

Absent and Concealed Penis.—In general, it may be said that such anomalies as absent, concealed or double penis, are of small importance except to those in search of medical curiosities. Complete absence of the penis has been recorded a number of times, but must be reckoned among the rarest of congenital anomalies. Concealed penis is not infrequently regarded as actual absence of the penis, but thorough examination later reveals at least a rudimentary penis hidden under the skin. This condition has been successfully remedied by a plastic operation, concerning which several reports have been made. This, of course, presupposes that no other deformity incompatible with life, is coincident with it. In those individuals who have reached manhood without any attention being given to the anomalous condition, the urinary meatus has usually occupied the normal position of the penis, or the subject has urinated through an opening into the rectum.

Much more important from the point of view of the ordinary clinician, are those congenital or acquired deformities of the penis frequently encountered, which require treatment, or more often, operation, for their correction.

Phimosis and Paraphimosis.—By phimosis we seek to designate that condition in which the opening in the prepuce is so small in relation to the size of the glans, as to prevent retraction of the prepuce over the glans. By paraphimosis we indicate any condition in which the prepuce exerts undue pressure or strangulation upon the glans. It is evident then, that paraphimosis necessarily implies a certain degree

of phimosis, for when the preputial ring is rather contracted, the glans on passing through it, will so force it back that it will be held in the sulcus behind the corona. But if the degree of phimosis is so great as to prevent the prepuce from being retracted at all, then paraphimosis cannot exist. It is, therefore, an acquired and not a congenital condition and must be classed as a pathological lesion rather than an anomaly.

It is necessary to differentiate between true phimosis and simple redundancy of the prepuce, even though the existence of any such

FIG. 14.—Paraphimosis of moderate degree. The tight preputial ring is clearly seen contracted behind the sulcus. This is reduced by exerting pressure upon the glans penis until the congested vessels of that structure are partially emptied. In case reduction is impossible, an incision is made through the tight band under local anesthesia.

redundancy may have an important bearing on the production of the acquired form of phimosis. The term *phimosis* has come to be rather loosely applied to long foreskins in general, whether or not it is possible to retract them. Often in babies and little boys the prepuce will be adherent.

Frequently, the terms hypertrophic and atrophic are used to differentiate two separate forms of phimosis. In the *hypertrophic* form we have a prepuce of sufficient size, but the distal opening is too small, while in the atrophic form, the prepuce is not only short, but much too narrow as well. Jefferson[37] demonstrated a few years ago, that it was

possible to observe either form of this condition upon the same patient at different times, and that this was due to the action of the peripenic muscle, which can not only alter the size of the preputial opening, but possibly with the assistance of a certain amount of shrinkage of the penis itself, cause an appearance of redundancy at one time while at another the prepuce will seem barely sufficient to cover the glans. It is the opinion of this investigator that a certain degree of phimosis is normal to infants, and that the redundancy of the prepuce which is so commonly observed at that age, is merely awaiting the develop-

FIG. 15.—Phimosis with two hard movable tumor masses retained which were composed of smegma.

ment of the corpora cavernosa and corpus spongiosum, which will take place when adolescence is reached, and "it is not until the penis undergoes its final development at puberty that the proper balance between the prepuce and the glans is struck." It would be interesting to have more evidence upon this point, as it would have an important bearing upon the necessity and advisability of many of the circumcisions now being done.

Results of Phimosis.—A great majority of the cases of true phimosis are not brought to the physician until some complicating circumstance

has arisen to direct attention especially to it, for the lay public is likely to be careless in such matters, and lack of proper cleanliness often leads to very distressing conditions. When it is difficult or impossible to retract the prepuce, smegma and other secretions quickly collect beneath it, and the irritation caused in this way is a frequent reason for establishing the habit of masturbation. Balanitis or balanoposthitis will be quickly set up by such a cause, and recurring attacks may lead to extensive adhesions between the apposing surfaces, so that even the small amount of retraction originally possible, will be permanently abolished.[37, 58] The measures necessary for the correction of such conditions will be mentioned later on.

Epispadias.—Though many cases of this anomaly have been reported, actually it is seldom encountered. Three forms are generally recognized; the *balanic*, the simplest type, where the urethral orifice is situated above and behind the glans; the *penile*, in which the opening lies between the glans and the symphysis pubis; and what may be termed *complete* epispadias combined with extrophy, in which the urethra lies open for its whole extent up to the bladder.

Epispadias in the female has but a comparatively slight resemblance to that occurring in the male. Indeed, in 1895, Ballantyne[2] remarked that "since the female may be regarded as a hypospadiac male, it has even been questioned whether in her epispadias is possible at all. It is now recognized that there is such a malformation, but it differs greatly in appearance from the corresponding anomaly in the male." Since Ballantyne wrote, a number of excellent studies of this condition in the female have appeared in literature. In her, epispadias may be said to consist of the displacement of the urethra to a point above the level of the clitoris, and a more or less extensive defect of the upper wall of the canal. The clitoris is usually split, its two sections rather widely separated, the imperfect urethra being in evidence above these two parts or above the membrane commonly connecting them. Thus we may have *partial epispadias*, where the deeper part of the dorsal wall is developed; *complete epispadias*, where the dorsal wall is entirely absent; and *subsymphyseal extroversion*, where the sphincter at the neck of the bladder is deficient and there is more or less protrusion below the symphysis of the mucous membrane of the posterior wall of the bladder.[2]

Balanic Epispadias.—The simplest form of male epispadias is, unfortunately, the most uncommon; only a few cases are on record. Here the subject presents a penis of normal form, though shorter than the average, and having a "spread-out" appearance. There is usually a furrow or groove on the upper surface of the glans, which is not pierced by any canal whatsoever, though in some instances the glans has been completely cleft in two.

Penile Epispadias.—In the penile form, the urethral opening lies on the upper surface of the penis, most commonly just in front of the symphysis. The glans and the scrotum are both in contact with the skin covering the wall of the abdomen, and the prepuce lies in an

extremely thick fold. The penis is seldom more than 1 or 2 inches in length, and will be seen to describe a decided upward curve, while upon its upper surface is a wide furrow with rounded edges and lined with mucous membrane, which sometimes extends from the glans to its base, or again only from the apex of the glans, or it may come to an end only a short distance behind the glans. This furrow terminates in a deep "funnel" partly concealed by the over-hanging folds of abdominal tegument. In one case the "imperforate, cherry-like glans, by being slightly curved upward, opposed itself against a projecting abdominal fold above. When the glans was pulled forward or downward, a short penis appeared, the upper portion of which showed a total absence of a urethral canal. Instead there was a broad furrow lined with a thin mucous membrane which continued into a large funnel-like orifice that permitted the introduction of a finger into the bladder. From this orifice slightly decomposed urine dribbled at short intervals. When the penis was left to itself the glans covered this opening like the cork on a bottle."[7]

If any part of the normal urethra is in evidence, it has usually a fair-sized lumen and the posterior portions of the corpora cavernosa will be well developed; but the prostate is very likely to be altogether missing, and in but a small number of subjects will the corpus spongiosum be present, the bulb being always very small.

Embryological Origin of Epispadias.—Perhaps the clearest explanation which has been offered of the origin of bladder extrophy and its frequent accompaniment, epispadias, is that put forward by D. Berry Hart[32] in 1901, and since frequently cited:

"A very important point as to the anterior boundary of the entodermal cloaca . . . is known as the cloacal membrane and, as was first pointed out by Kölliker, and afterward confirmed by others, it has, at one time, no mesoblast, and is thus a part structurally weak. The upper boundary of this membrane is the navel, and its lower, the junction of the end gut and ectodermal cloaca. In the adult this lower point is on the perineal body in front of the anus, as in . . . persistent end-gut in a female child . . . . In the adult, therefore, the cloacal membrane is represented by the mesial region from navel back to perineal body -the anterior boundary of the bladder, urethra, pubes and vestibule. . . .

"The best explanation of extroversion is afforded by the facts now known as to bladder development and the cloacal membrane. The bladder in the human female is not developed from allantois except at its apex, but is derived along with the urogenital sinus from the anterior division of the entodermal cloaca. This cloaca has the cloaca membrane as its anterior boundary, and as this boundary has no mesoderm at one period, it may yield or cleave. This yielding if complete, necessarily exposes all that is derived from the anterior primitive gut division *viz.*, bladder, urogenital sinus, lower third of vagina. . . . Less degrees of fissure in linear extent or depth, give other lesions. These are therefore, explained as Keibel has so well shown, by the

actual development of the parts *plus* some bursting or dilating cause which, if it does occur . . . must do so at an early period of embryonic life."

Effects of Epispadias.—The existence of epispadias in the male leads to a number of very distressing conditions. Urinary incontinence is always more or less complete, and because of this, as well as because of the fact that the urine issues from the base of the penis, the skin covering the suprapubic region will, from infancy, be in a constant state of inflammation and maceration, at times being badly ulcerated. The situation of the penis itself, bears such a relation to the wall of the abdomen that the urinary stream, instead of curving outward, is directed vertically upward so that the pubis is continually bathed with urine. This deviation of the penis, as well as its small size, render coitus very difficult, even in the most favorable cases, or more frequently, quite impossible, and even in the event of sexual connection taking place, the fact that the seminal fluid must be ejected at the peno-pubic junction, makes it extremely unlikely that it will effect impregnation.

In childhood, the inability to control the urine will cause great discomfort and mental distress, sufficient to effect the child's whole attitude toward life, while the sexual difficulties which come into prominence after puberty, have frequently occasioned so much psychic disturbance as to induce these unfortunates to commit suicide. Any effort on the part of the medical attendant to remedy the condition would seem to be justified under the circumstances, and despite the many difficulties with which it is attended, relief has been afforded in a number of recorded cases.

Operations for the Relief of Epispadias.—It is only in comparatively recent literature that we find very encouraging reports in regard to complete restoration to normal after operation for the correction of epispadias. Though the defect in the vesical wall was frequently repaired in both males and females, the urinary incontinence was seldom corrected, and even in those cases where the penis was dislocated so as to assume its normal angle, sexual ability did not reach its ordinary level.

Beck's Operation.—An attempt was made by Beck in 1906 to form a urethra by dissection of the lining of the "funnel" which he "pleated like a shirt-front," drew through an aperture made in the imperforate glans for that purpose, and sutured to the summit so as to form a meatus. The penis, was lengthened by the insertion of a small triangular skinflap between it and the abdomen, formed from the redundant foreskin. The penis however, remained short, though its position and direction were normal, but control of urine was established.[7]

Barney's Operation.—Barney's procedure[4] consists in dividing the urethral gutter longitudinally and using the redundant prepuce to form a roof over it, by means of a button-hole incision through it just below the frenum. The lower edge of the prepuce is denuded, as is also the fold of pubic skin over the urethra at the penile root. The

glans is drawn through the button-hole slit so that the denuded lower edge of the prepuce comes well up on the penile shaft, and the cut edges sutured together, the always-present redundancy of the prepuce, permitting this to be accomplished without tension. The posterior urethra is completely roofed in by the plastic flap which can be readily retracted like a normal prepuce. In adults the entire procedure can be carried out under regional anesthesia, but in infants and little boys, the originator prefers full ether narcosis.

Transplantation of the ureters has been frequently advocated for the relief of epispadias, but the reported results are not very encouraging. The Scotch surgeon, Stiles[69] reported 2 successful cases in little girls when he was the guest of the American Surgical Association in

FIG. 16.—Complete epispadias with incontinence of urine. The penis is retracted upward and skin of that organ is collected in a mass below. This boy aged twelve years was operated upon by the Cantwell-Young method and cured. Difficulty was encountered in relieving the terminal part of the urethra from pressure which caused necrosis. This was finally overcome by splitting the glans penis entirely into two parts.

1911, and a Canadian, F. N. G. Starr[67] carried out a similar procedure on a boy aged eight years several years later. Starr's patient died of pneumonia on the tenth postoperative day, and apparently no further attempt of the sort has been made on this continent.

Young's Operation.—The most recently introduced and apparently the most successful procedure, at least 5 cases showing excellent results from every standpoint, is that which Young described in 1917.[83] In his original presentation, Young was careful to state that a very similar procedure had been advocated and carried out by Cantwell in 1895,[15] although Young did not know of Cantwell's work until he had done his own operation several times.

The penis is held in position by two sutures placed in the glans. On the left side of the groove upon the dorsum of the penis an incision

is carried through the skin down to the corpus, but on the right dissection is carried down between the corpora until the skin of the under surface of the penis is reached. The skin edge is retracted to the right, and the right edge of the urethral groove brought over to the left edge and the cut edges sutured over a catheter, thus converting the original into a tube, which is however, still attached to the underlying left corpus. The left corpus is now rotated in such a way as to carry the urethra down to a new position between and below the two corpora, which are sutured with interrupted sutures of chromic catgut. The two outer edges of the original incision are now brought together in the mid-line, the end-result producing a penis and glans almost normal in appearance. One of the most important features of this procedure is the plan of leaving the skin for the new urethra attached to one corpus cavernosum in order to secure adequate blood supply.

Hypospadias.—Hypospadias is the opposite of epispadias in that the opening into the urethra is on the under side of the penis, but similarly this deformity is also manifested in three different ways, the balanic, the penile and the perineal. In the first-named type the opening is in the glans, but instead of occupying the normal location at the summit it is somewhat below it. In the penile variety the opening may be anywhere from the glans to the point where the penis joins the scrotum. In the perineal type the opening is found wholly in the perineum, or possibly in a cleft of the scrotum. As hypospadias is a not uncommon deformity, and is frequently associated with other anomalous conditions in the genito-urinary organs, one is likely to encounter variations from any of the types just described. Thus, in a case of "pseudo-hermaphrodismus maculinus" recently reported[83] "the urinary meatus was at the peno-scrotal junction, the scrotum contained no testicles nor cords, was bifid in character and presented the appearance of labia majora, but no suggestion of labia minora." Abdominal incision and careful search failed to locate any testicles, no prostate could be made out and no seminal vesicles were visible.

Balanic Hypospadias.—The urethral opening is in the position normally occupied by the frenum in the balanic type of hypospadias. Occasionally there will be two or even more openings. An open groove runs along the normal position of the urethra from the anomalous opening to the point where the normal meatus should open, the glans being much shorter than normal, and usually imperforate, though it may be pierced by an opening which is separated from the urethra by a blind sac. At the dorsum of the penis the foreskin will be short and very thick, but as it approaches the urethral meatus it becomes thinner. In the fully-developed adult the penis will be more or less deflected downward at the point where the hypospadias begins.

Penile Form.—In the penile type of hypospadias, the meatus will be found at any point between the scrotum and the glans, and will be an oval opening instead of the transverse shape usually observed in the balanic type. The urethral canal does not extend beyond the point of opening, a deep groove upon the surface usually marking its normal

route. Sometimes the scrotum, which will be situated underneath the urethra, will be completely cleft, and the corpora cavernosa likewise may be separated. Occasionally there will be a perfect canal beyond the anomalous opening, but the meatus at the tip of the glans will be imperforate or very greatly strictured. The penis is always much shorter than the normal organ and exhibits a downward curve.

Perineal Hypospadias.—As the perineal form is by far the most difficult condition to remedy, it is extremely fortunate that it is the most seldom encountered of the three chief types which this deformity displays. Here a slit-like opening lies in the groove which divides the scrotum into two portions, the anomalous meatus being a distance of

Fig. 17.—Epispadias. Urethra opens at penoscrotal junction.

not more than 3 or 4 cm. from the anus. Labia-like folds of mucocutaneous tissue lie on either side of this orifice, so that it has somewhat the appearance of a small vagina.[30] The urethra will usually be found to extend some distance beyond the anomalous opening, and may end as a blind sac in any part of its normal course, the normal meatus at the summit of the glans, however, being uniformly imperforate. The victim of this particular type of deformity is obliged to sit down to urinate, owing to the force with which the urinary stream is projected from the membranous and prostatic portions of the urethra which do not share in the deformity. In the other forms, although the angle of the penis is abnormal, it may usually be held in such a way

as to direct the stream so that it will not wet the person of the subject. But all such unfortunates have much difficulty in keeping themselves clean and avoiding the conveyance of an objectionable, ever-present odor of urine.

Though it is a fact that many boys are born hypospadiacs, grow into manhood, marry and create offspring,[8] though sexual intercourse can be carried out in the presence of the balanic or penile types of hypospadias, in the perineal form the deformity is so great as to prohibit intromission entirely, and in most of the penile cases the urethral opening is so far from the glans as to bring it outside the vagina during sexual contact, thus defeating impregnation. The deformity thus becomes a source of great mental distress to many adults, even though its concealment can be much more easily accomplished than is the case with epispadias, and we find that from very early times the efforts of surgeons have been continually enlisted for its correction.

Operative Methods.—The various types of operation used to correct hypospadias have been classified as: (1) The method of simple canalization; (2) that by denudation and suture; (3) that by the use of penile flaps; (4) that by taking flaps from the abdomen or scrotum; (5) a method combining the principles of the four previous methods, and (6) the method of mobilization and dislocation of the urethra.[10]

The earlier plastic operations, that of Diffenbach, which consisted in piercing the glans to the beginning of the normal urethra and keeping this new passage patent by means of a cannula until an epithelial lining had formed, the abnormal opening being sewed up; that of Duplay, using a flap of prepuce to cover the defect and form a new urethra; or Thiersch's plan of employing double penile skin flaps, the base of one being near the urethral groove, the other on the opposite side of the penis—were all open to very serious objections. The field of operation is very difficult to render sterile; flaps are made too small, and closed under tension; dressings become soaked with urine; frequent erections are a source of much discomfort to the patient, and after the third day the catheter fixed in the canal is often expelled by the straining of an irritable bladder, or the urine runs along the side of the instrument, instead of through its lumen.

Beck's Operation.—In 1897 Carl Beck of New York introduced a method of dislocation of the urethra which was extensively practiced. An incision is made parallel to, and at one side of the urethra, and about 2 inches—a length sufficient not to cause too much tension when the forward dislocation takes place —of the urethra dissected out. A new channel is made through the glans by means of a bistoury large enough to allow for some contraction later on. Four thin silk sutures are run at equal distances from one another through the anterior opening of the urethra. The ends are drawn through the new channel in the glans and, using the silk threads as a handle, the urethra is pulled forward into its natural position. The sutures are rethreaded on a needle, and the urethra is stitched to the circumference of the freshly

created meatus. One of the ends may be left long enough to run through or around the catheter which has been used as a guide, to keep it from sliding either in or out. The wound in the body of the penis is closed with a fine catgut suture, a thin strip of sterile gauze is

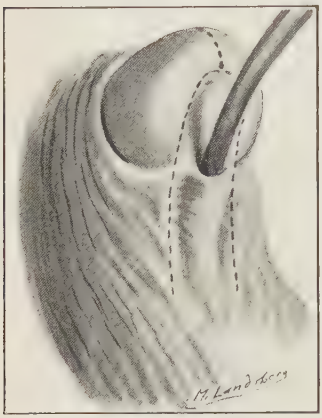

FIG. 18

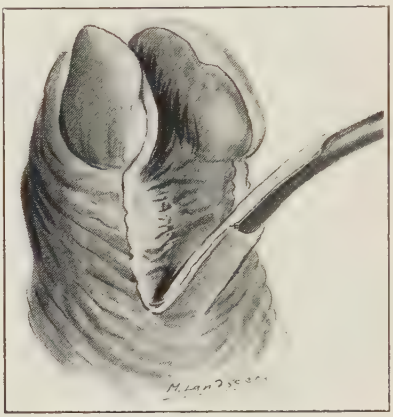

FIG. 19

FIG. 18.—Hypospadias—showing lines of incision.

FIG. 19.—Hypospadias showing wide flap of urethral mucosa and skin incised in such a manner that it may be used to cover a small catheter which is left in only long enough to complete the construction of the canal. The glans penis is split entirely into two parts so that there will be no undue pull on the newly-formed urethral canal.

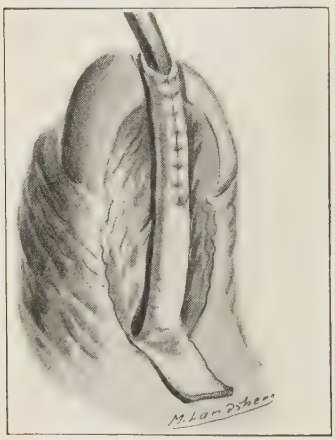

FIG. 20

FIG. 21

FIG. 20.—The urethra has been freely dissected so that with the repaired portion it extends a little beyond the end of penis.

FIG. 21.—Repair completed. Following this the patient is immediately subjected to a suprapubic cystostomy which is kept open until the wound is entirely healed. Urine escaping to the region of the wound is almost sure to cause necrosis. As soon as the operation is completed the small catheter is removed from the urethra and every effort made to prevent pressure of any sort upon the wound.

placed over it, and the whole encased in an adhesive or collodion dressing. Large doses of potassium bromide and a bland diet must be employed to control erections, which will cause operative failure by interfering with primary union.

Faults of the Beck Operation.—The objections to this procedure are that it greatly shortens the under surface of the penis, putting it under great tension, and by producing scar tissue for a considerable distance around the urethra is instrumental in causing general contraction.

FIG. 22.—There is an extensive hematoma of the penis shown here. The exciting cause was trifling. The condition cleared up in about eight days without suppuration or other complication.

To overcome these objections, Bevan[10] six or seven years ago, suggested making a new part of the urethra entirely from a skin flap without buried sutures of any kind, the skin flap being so formed as to constitute a tube of large caliber which is very elastic, and in time contracts down to a tube of the desired size. This makes the use of a catheter unnecessary, and does not require drainage of the bladder by a stab-wound in the perineum. It does not interfere in any way with the previously-existing urethra, so that there is no danger of damage to that organ.

INJURIES TO THE PENIS.

Traumatic injury to the penis is of far less frequent occurrence than one would suppose on account of its relatively exposed anatomical position. Actually, it is seldom accidentally injured, except when in erection, and even in extensive trauma, such as that due to war wounds or industrial accidents, suffers no greater damage than the surrounding parts.

Gunshot Wounds.—Gunshot wounds occurred quite often during the World War. Some of them were surprisingly trifling. Morestin's patient[51] was recovering from a shrapnel fracture of the superior maxilla, and a slight wound in the left thigh, when he discovered a hard roundish mass in the tissues of his penis. During a month's stay in the hospital there had been no symptoms to attract attention to the penis, yet exploration showed that a bullet had entered below and in front of the left great trochanter, traversed horizontally the base of the thigh and the dangerous region of Scarpa's triangle without injuring it, passed beneath the left spermatic cord without touching it, pierced the left corpus cavernosum, and finally lodged in the depths of the right cavernous body, whence it was extracted without any difficulty, leaving an aseptic wound which healed without any cicatricial distortion of the penis, or the least disturbance of function. Lavenant and Lostalot[43] have reported a similar case, the only inconvenience suffered by their patient being a slight retardation in the flow of urine.

Very extensive injuries have been reported by other surgeons, however. In Walther's case[78] the left testicle was denuded and the lower part of the glans, with the corresponding portion of the prepuce and anterior extremity of the urethra completely destroyed. In 2 of Rochet and Richer's cases, the penis was completely severed, "merely hanging by a shred of prepuce." In 2 other cases the urethra was cut through, but the wound did not extend the entire thickness of the penis. In all 4 cases the base of the glans or very near it, was the site of the penile wound.[60] Four extensive plastic operations for repair of a badly wounded penis were successfully carried out by de Sard.[22] In one patient nothing remained of the organ but "a shrivelled shred of tissue," and both testicles had been lost. The suspensory ligament of the penis was severed and a channel made to the posterior urethra, which was brought down through a vertical incision in the scrotal tissue, to a new meatus near the base. Eventually the patient was able to urinate without difficulty. In both the cases of complete severance, the parts were reconstructed so that urination was practically normal. One patient had normal ejaculation but erection was only partial, and there was considerable deviation toward the left. Erection was perfect in the other patient. In the case reported by Le Fur,[41] cicatrization of a shell wound in the penis caused induration of the left corpus cavernosum and brought about priapism which was absolutely unaffected by seda-

tive measures, but subsided after a plastic operation upon the scar tissue.

Constriction.—Constriction of the penis may lead to serious consequences, even gangrene and loss of the entire organ. Numerous instances are on record where metal rings[24] have been slipped on over

FIG. 23.—A superstition exists among certain ignorant people that a wedding ring slipped over the penis of one suffering from acute gonorrhea will have a curative effect. The accompanying photograph shows a gangrene of the terminal third of the penis as a result of this nefarious practice.

[1] This case and many others quoted and demonstrated in this publication occurred on the urologic service of Dr. E. L. Keyes, Jr. and Dr. Alfred T. Osgood at Bellevue Hospital while the authors were members of the staff at that institution. Deepest gratitude is felt for the privilege of using this material.

the shaft, the quickly produced edema soon preventing their removal. Stephens[68] reports 2 cases of "penis captivus," 1 in a married man, aged fifty-four years, whose penis was found to be enormously swollen and edematous because of pressure from a wedding ring which he claimed his wife had put on him while he was asleep in a chair. A similar case is related by Bottescelle.[11] Stephens' other patient was a young unmarried man who inserted his penis in a stone hot-water bottle, and was wholly unable to withdraw it. In both cases the anguish was entirely mental, no pain being experienced.

FIG. 24.—This young man shows a scar of the penis due to having had a string tied around it for several days in his youth. (Bellevue case.)

A string tied about the penis of a nine-year old colored boy seen by Gelphi,[27] had almost completely severed that organ about ½-inch from the pubis. The string had remained about the penis for eight days and had cut through the urethra and the dorsal vessels, as well as the central arteries of the corpora cavernosa. Despite the great damage to the circulation, persistent efforts finally succeeded in inducing healing, both of the urethra and the tissues of the penis. The urinary function was entirely normal, but the child was too young to permit an estimate of erection and sexual function.

When the contusions are severe they may cause such marked ecchymosis and edema as to simulate a rapid gangrenous process. Hematoma, small circumscribed tumors most prominent during erection,

will result from the rupture of the vessels supplying the corpora cavernosa. When the urethra has been injured, blood will appear at the meatus, and the usual manifestations of inflammation be quickly in evidence. A case of serious laceration of the penis, said to be due to an attempt to have intercourse through a barbed-wire fence, came to the authors' attention when a number of sailors were held in quarantine for a long period because of the influenza epidemic. In another instance a man found a darning needle on the street and put it in his pocket. Later, a box which he was lifting caught on the needle and forced it through his penis, the resulting wound causing extravasation of urine.

Denudation.—Cases have been reported where the penis has been completely denuded.[17] Powers' patient was a six-year old boy who was injured in a barbed-wire fence. The skin of the penis was completely everted, having, been "peeled off much as one would evert the finger of a glove in removing it."[53] The skin was replaced after the "questionable tissue" had been excised, and after some sloughing, the wound healed so that there was no constriction at the base of the penis, the skin was freely movable, and the appearance practically normal.

Fracture of the Penis.—Fracture of the penis when in a state of erection, most frequently during coitus, is occasionally recorded.[82] Malis[47] published a case where the subject caused such a fracture by depressing the penis with his hand in order to stop an erection. The patient usually tells of having heard a "cracking sound," immediately followed by collapse of the erection and pain, with later swelling and edema. Attempts to "break" chordee sometimes result in fracture, which may be accompanied by rupture of the urethra, with subsequent extravasation of urine. Hemorrhage too, may be very severe.

Treatment.—Contusions are best treated by rest, elevation of the parts, and hot antiseptic applications. If the condition does not improve, an incision should be made under strict antiseptic precautions, so that any bleeding vessels may be ligated. The first indication of emphysema demands free incision, and the same is true should there be signs of suppuration, for ample and thorough drainage is of the utmost importance. When the urethra is involved, a catheter should be passed all the way to the bladder and allowed to remain in position for a week or longer. Occasionally it may be found impossible to pass an instrument from before backward. Under such circumstances a perineal section should be performed and retrograde catheterization done. The bladder may be drained per perinaeum until the lacerations have healed.

Incised Wounds. Incised wounds, if not very deep, heal quickly provided they receive prompt attention. From deep wounds involving the erectile tissue there will be very free hemorrhage, and loss of the power of erection in the area anterior to the wound frequently follows. If the penis has been severed completely, the hemorrhage may be so great as to be quickly fatal, unless hemostasis can be at once estab-

lished. Hemorrhage should in all cases be controlled by ligature; mere venous oozing can be checked in most cases simply by apposition of the cut surfaces. If hemostasis cannot be thus brought about, a hard rubber catheter should be introduced into the urethra and the entire penis swathed in a tight roller bandage. Erections may be prevented by the administration of morphine or sodium bromide. It is considered the best practice always to attempt to suture a divided penis, even though there is a likelihood that the later formation of cicatricial tissue may distort the organ to such an extent as to render erection imperfect and painful. The great progress recently made in plastic surgery of these parts offers encouragement in even the gravest injuries. When the urethra is severed, it should be anastomosed as well as possible, and a catheter introduced through a perineal incision into the bladder for the purpose of drainage and to prevent urinary extravasation. The catheter can usually be removed at the end of a week.

Punctured Wounds.—Punctured wounds should always be incised to establish adequate drainage and avoid infection. Fracture of the penis may at times be adequately treated merely by dressing the injured organ with compresses wet with lead and opium solution, and bandaging firmly against the abdominal wall. If there is injury to the vessels of the corpora cavernosa, the penis may have to be incised, the clots evacuated, all the bleeding vessels ligated and the resulting wounds carefully sutured. A catheter should be left *in situ*, and the entire organ protected by an antiseptic dressing bandaged firmly in place. At the end of the second day, the catheter should be removed and the dressing renewed. The bowels must be kept freely open so as to prevent erections, and sedatives may have to be administered for the same purpose. In Stephens' case healing took place quite readily but a lump remained in the corpus cavernosum, so that the terminal part of the penis was functionally worthless. This made the patient so melancholy that operation was undertaken. A clot of blood the size of a cherry was evacuated and its cavity obliterated by excising the outer wall and accurately uniting the cut edges of the tunica albuginea. Full functional activity was regained. Stephens recommends that operation in such cases should be postponed until all the superficial effusion has been removed, which usually takes about ten days. On the other hand, delay beyond fourteen days will diminish the likelihood of a good functional result, owing to the commencing fibrosis.

Constriction of the penis is usually sufficiently treated by removal of the constricting body, a return to normal conditions commonly following. If a ring cannot be slipped off, a tape bandage may be so applied as to compress the edematous part in front of the ring, or the band may be cut with scissors or a file. If ulceration occurs it may cause a circular scar which will interfere with erection in the distal part.[40]

Dislocation of the Penis.—Dislocation of the penis may sometimes occur when violent trauma has taken place. The skin remains in

position, but the attachment of the skin behind the glans is torn free, so that the glans and the body of the penis are forced backward, and will sometimes be found in the scrotum, the subcutaneous tissue of the pubis, or even in the groin. If the urethra has been ruptured, extensive extravasation of urine may greatly complicate the diagnosis. The dislocated penis should be reduced to its normal position and the results of trauma repaired as in other types of injury. Sometimes it may be brought down by a hook passed through the meatus, but more often incision will be necessary.

DISEASES OF PENIS AND PREPUCE.

Balanitis.—Balanitis or balanoposthitis is an inflammation of the surface of the glans penis with a posthitis of the mucus lining of the prepuce. It not infrequently occurs as a complication of gonorrhea, and in general is due to the retention of irritating secretions, a condition favored by a congenitally long prepuce, or by neglect of personal cleanliness. The mucosa of the glans and prepuce becomes damp and red, accompanied by intense itching and the exudation of an evil-smelling, creamy-white discharge. Frequently the swelling will be so great as to induce an inflammatory phimosis, and there may be ulcer formation which will closely simulate chancroid.

Chronic Balanitis.—Chronic balanitis is a less virulent inflammation which is more likely to appear in middle-aged or elderly subjects in whom the prepuce has become pendulous through muscular relaxation. The mucous membrane of the penis eventually becomes much thickened, and on retraction will be observed to be covered with granulations or possibly by areas of excoriation.

Erosive and Gangrenous Balanitis.—Erosive and gangrenous balanitis is a contagious form which was first described in 1889 by Bataille and Berdal, the causative organism being isolated and identified by Scherber and Müller in 1904, who also named the condition "the fourth venereal disease." In this country Corbus of Chicago[16] has been the chief contributor to our knowledge of this pathological entity. He defines it as a specific infectious venereal disease due to symbiosis of a vibrio and a spirochete, with local and constitutional symptoms. varying with the severity of the infection.

Etiology.—Predisposing causes are: A congenitally long and tight foreskin; wetting the penis with saliva; or unnatural sexual practices.

Bacteriology.—The bacteriological picture is morphologically identical with that seen in Vincent's angina, noma or ulcero-membranous stomatitis, all of which are affections of the mucous membrane. The vibrio or fusiform bacillus is a weakly Gram-positive organism about 0.8 μ wide by 2 μ long, of a spindle-shape, and shows one or more granules in the central portion. It shows no motility under the dark field. This form can be grown on ascitic or serum agar under

strict anaërobic conditions, where it appears in the form of short rods, at times filamentous in character.

Compared to the *pallida* type, the spirochete mentioned by Corbus is rather thick, and possesses a very active motility, there being both a wave-like and a rotary movement. It is about 0.2 μ wide and varies in length from 5 to 15 μ. The spirals, of which there are usually from six to ten, are about $\frac{3}{4}$ μ in width and are not as numerous nor as fine and regular as those observed in the *Treponema pallidum*. Both the fusiform bacillus and the spirochete stain readily with dilute carbol-fuchsin, another point distinguishing the latter from the pallida.[16]

The symbiotic organisms can be present in the mouth and remain wholly innocuous; transferred to the genital region, however, they are likely to develop a marked virulence capable of producing ulceration and even gangrene. In practically all cases a history of contamination with saliva can be elicited by careful questioning, though a few are on record where no such history could be obtained.[53]

Symptoms.—If the patient comes under observation before marked phimosis has developed, on retracting the prepuce and wiping away the pus, small round ulcers will be seen within the eroded areas. These ulcers are described by Corbus as moderately deep, quite flat, surrounded by a red zone and covered by a closely adherent pseudo-membrane. They may be even deeper and more extensive becoming confluent and extending over the whole surface of the sulcus, or the inner surface of the foreskin. Balanitic ulcers are somewhat irregular in outline and surrounded by a small, slightly inflammatory, somewhat elevated border. This border is sharply differentiated, with slightly slanting sides and an under-base which is often covered with a swollen and edematous membrane of a yellowish color. When more edematous, this false membrane appears as a sort of friable slime. Here and there may be hemorrhagic spots which sometimes give rise to hemorrhage from the base of the ulcer.

Constitutional symptoms, such as nausea, vomiting, chills and rise of temperature, are evident in the more severe cases. The external skin becomes very edematous, the infiltration sometimes reaching as high as the root of the penis. The inguinal glands will be enlarged, as will also the dorsal lymph cord, but no pain accompanies even intense swelling. Neither is there any pain connected with micturition, except in those cases where phimosis is very marked. When this is sufficient to retard the evacuation of urine enough to dilate the preputial sac, there may be complaint of pain.

Balanitis gangrenosa is commonly associated with great edema of the subcutaneous tissue of the penis, which extends to the root and produces an extreme degree of phimosis. If the ulcer is situated on the inner surface of the foreskin it shows externally as a dark, bluish-red area within the surrounding bright red inflammatory tissue. The congestion and abnormal pressure, due to edema, favor in a marked degree the progress of the disease. Soon the foreskin over the ulcer

PLATE I

Section Through Glans Penis and Prepuce of Case Suffering from Condylomata Acuminata.

This section was made by Prof. E. Christeller in accordance with his original method and presented to the authors for use in this text-book. The sections are cut sufficiently thin to be studied microscopically, after having been subjected to freezing on a specially constructed freezing stage. They are then stained. The entire procedure takes only a few hours. *a*, Corpus spongiosum; *b*, tunica fibrosa; *c*, septum fibrosum; *d* glans penis; *e*, urethra; *f*, outer epithelium of prepuce unaffected; *g*, inner lining of prepuce unaffected by papillomatous growth; *h*, papillomatous growths of glans penis; *i*, condylomata acuminata of under surface of prepuce.

becomes black and a complete necrosis of the part occurs. If the ulcer is situated on the glans, in a short time it will produce complete destruction of the same, or may cause an extremely rapid gangrene of the organ, extending even to the root of the penis.

Treatment.—As a long foreskin is an absolute prerequisite for the propagation of these anaërobic bacteria, it never attacks those who have been circumcised, and the encouragement of this practice would tend to lessen the incidence of balanitis. If phimosis has not had time to become marked, mechanical cleansing of the retracted foreskin should be followed by applications of peroxide of hydrogen, as the liberation of oxygen is fatal to all aërobic bacteria. All sloughing tissue should be carefully removed and dressings well wet with hydrogen peroxide applied. Should it be impossible to retract the prepuce, recourse must be had to incision, so that the infected area may be exposed and thoroughly dried and irrigated. Cauterization is sometimes employed, but its use is neither wise nor necessary, as the local applications meet all the requirements. In those rare instances where hydrogen peroxide fails to cure, injections of the arsphenamine compounds as they are employed in Vincent's angina, may be necessary, and if gangrene has already begun, they should always be employed in conjunction with the local treatment.

Streptococcic Balano-preputial Intertrigo.—Streptococcic balanopreputial intertrigo has been described by Montgomery[19] in a case of transference of infection to the penis from a streptococcic lesion of the left leg. The lesion was circular, smooth, red, raised and sharply contoured, and was situated on the right side of the glans, the sulcus and the corresponding surface of the prepuce being so placed that when the prepuce was drawn forward the red surface folded accurately into apposition. A crack, such as is seen behind the ear in strepto-dermatitis of that region, lay in the sulcus at the bottom of the preputial fold, its edge elevated, so as to give an impression of rolled induration suggestive of chancre. Such lesions usually clear up readily under the treatment ordinarily applied to dermatitis of this general type. Differential diagnosis is only occasionally difficult, and these obscurities can ordinarily be dispelled by the microscope.

Venereal Warts.—Venereal warts, verrucæ or papillomata are most commonly found on the coronary sulcus or the posterior edge of the glans, less frequently, upon the inner margin and surface of the prepuce, and occasionally at the meatus, or near the frenum. They arise from an undue proliferation of both epithelium and connective tissue, are papillary in type, and usually highly vascular. The adjective *venereal* is distinctly misleading, for though these growths are most frequently found in those who have had gonorrhea or syphilis, their primary cause is irritation of the skin or mucous membrane by long-continued contact with inflammatory exudates. Such a discharge, though most commonly gonorrheal, is not necessarily so, and the state of irritation as a result of which they arise is dependent upon phimosis or a long prepuce.

Congenital predisposition probably also plays some part in the incidence of verruca. Though there are records of these warts being experimentally produced in animals by inoculation, proof that they are contagious is still wanting. Wile and Kingery[51] found that a sterile filtrate of wart material injected subcutaneously, produced localized hyperkeratosis, clinically and pathologically identical with verruca vulgaris. This led them to believe that interpapillary hypertrophy, inflammation and marked keratosis occur as secondary traumatic manifestations, and while such localized keratosis may be due to trauma or the presence of foreign bodies, it is not improbable that these merely act as inciting factors, providing a portal of entry for the infective agent.

FIG. 25

FIG. 26

FIG. 27

FIG. 25.—Venereal warts of moderate degree are shown here. The best cure for this condition is circumcision with complete extirpation of the verrucæ and the tight moist prepuce which causes them at one and the same time. Very few authentic cases of carcinoma of the penis have occurred among men who have been circumcised.

FIG. 26.—The excision is made sufficiently extensive to remove all the masses. Bleeding points are clamped and tied off.

FIG. 27.—The cut ends are then approximated in the customary manner.

Condylomata. Condylomata appear most frequently in the early years of sexual activity and flourish where personal cleanliness is not observed, being frequently seen in clinics, but rarely encountered in the better class of private practice. The warts assume various shapes, according to their location, sometimes appearing in "raspberry" or "cauliflower" shape, or again projecting like threads. In certain locations, as beneath the prepuce and the glans, the pressure of the surrounding structures may reduce them to flat plaque-like shapes.

Prophylaxis.—Prophylaxis consists in cleanliness and the removal of the cause of irritation. When allowed to remain filthy and untreated, ulceration and suppuration will eventually take place, and it is probable that the area thus affected will be predisposed to malignancy.

Operation.—Small growths may be snipped off with scissors under local anesthesia. If they project sufficiently they are easily drawn up with a rat-tooth forceps, so that the base can be completely excised. Those upon the glans penis will bleed more freely than elsewhere, necessitating cauterization of the bleeding-points. Sometimes if a large growth has been thus removed from the prepuce, it may be necessary to suture the resulting wound.

Flattened condylomata, so spread out as to have a wide base, are sometimes more easily extirpated by a "shaving operation," but as this partakes more of the nature of a major procedure it will require complete anesthesia which may be satisfactorily induced by the sacral or parasacral method. It is usually desirable to circumcise the patient at the same time, thus doing away with the predisposing cause of the warty condition. Curettage and cauterization of the wound left by the removal of the growth will be followed by prompt healing if the irritants which originally induced the proliferation of the condylomata are abolished.

Local Treatment.—Local treatment recommended is the application of nitric or chromic acid, or similar cauterizing agents. This treatment, in the authors' opinion, is objectionable, as such applications may be toxic in certain cases, and have even been known to act as exciting irritants, increasing the difficulty instead of halting it. Venereal warts so treated have also been known to progress to malignancy.[45] The application of 40 per cent formaldehyde solution has proved to be efficacious in some cases.

Fulguration has been successfully employed by a number of operators.

Induration of the Penis.—Plastic induration of the penis has been defined by Ercoli as a non-inflammatory condition, the etiology of which is unknown, occurring quite apart from any local affection of the penis, or any general systemic disease. It begins as a thickening of the tunica albuginea and the septa of connective tissue between the corpus spongiosum and the corpora cavernosa, gradually extending to the spongy and cavernous bodies themselves.[23]

Until a few years ago induration was looked upon as a very rare finding. Gerster and Mandelbaum[28] writing in 1913 stated that "the formation of bone in the human penis is one of the rarest of phenomena," and reckoned that the case which they presented was only the sixteenth to be recorded in literature. Since then however, discussion and case reports of this condition have been more frequent, and two years ago the publications from the Hospital Necker were authority for the statement that Legueu operates at least 5 or 6 of these cases every year.[42] He describes it as a lesion relatively common at a certain period of life and very disagreeable, at once for the individual who suffers it, and the surgeon charged with treating it, because all the therapeutic efforts directed toward it are so seldom satisfactory.

Etiology.—The etiological factor in the production of these indurations is unknown. Ercoli believes it to be a philogenetic phenomenon,

a return to a condition normal to certain animals which have a thick fibrous cord or nodule in the septum between the corpora cavernosa, or even the bony penis described by Leydig. Gerster's patient had a luetic history and for a period of three years had worn a corset of the straight front variety, the anterior rim of which impinged on the upper aspect of the root of the penis. Sachs[62] collected records of a large number of probable cases of plastic induration of the penis and from their examination concluded that venereal disease, and probably diabetes and gout, may be of etiological significance, while trauma almost surely is. The fact that these formations practically never appear before the fourth or fifth decade, led Zur Verth[45] to believe that the arteriosclerosis common to that time of life, such as is due to alcoholic or other intoxications, might act in combination with the effect of the constantly-repeated slight trauma undergone during erection and coitus, to produce the lamella-shaped bodies on the upper surface of the penis, which later undergo ossification. Induration always begins in the penile fascia where there are many elastic fibers, and this author regards the process as a degeneration similar to that which goes on in the walls of the bloodvessels during senescence.

According to Legueu it is simply a cicatricial alteration, producing at first greater and greater density of the connective tissue, and later osseous tissue, which is at first disseminated and then coalesces into a continuous plaque. Consequently, when we find true bone formation, we should not regard it as a regressive alteration, but merely conclude that this particular patient has been developing the lesion for a time sufficiently extended to permit osseous formation. A direct transition of connective tissue into true bone tissue was noted in the histological examination made by Rothschild,[61] who also attributes the production of induration to the tension to which the coverings of the penis are subjected during erection and sexual connection. Tension is exerted at the point of greatest pressure, and this predisposes to connective tissue degeneration. He can however, offer no explanation of why connective tissue only is produced in one individual, and bone formation in another.

Symptoms.—Indurations of the penis usually assume a lamellary or testaceous form, the osseous surface being frequently broken by areas of connective tissue. They are most commonly observed on the dorsum of the penis, at the internal aspect of the tunica albuginea; less frequently in the septum and corpora cavernosa, or rarely in the erectile tissue, or even as far forward as the glans. The patient's chief complaint is inability to copulate, for during erection the distal part of the penis deviates upward or to the side,[34] and erection may become extremely painful. In some cases urination is impeded, but this is relatively rare.

Treatment.—Surgical removal is the remedy most commonly applied, but in many cases it has proved unsatisfactory and has been speedily followed by recurrence, the cicatricial condition induced by the inter-

PLATE II

Granuloma Inguinale. (After Randall.)

The overgrowth of granulation tissue, bright red in color, is shown quite characteristically in the picture. Several small moist papules are noted surrounding the older ulcerations. A few of these have broken down and give an excellent idea of the earliest lesions.

vention only increasing the original difficulty. Sonntag[66] established that surgery cured about 75 per cent of the cases. Legueu warns against attempting to operate unless the area of induration is sharply limited; if the indurated nodules are disseminated there is small likelihood of complete restoration of form and alignment of the penis. after they are excised and scar-tissue formation has taken place.

Legueu's Method.—In operating the base of the penis must be ligated, as hemorrhage is always abundant. After the bony plaque has been removed, the defect may be repaired by a plastic operation. A flap from the aponeurosis of the fascia lata is elevated upon the thigh, and the ligature at the base of the penis having been removed, several silkworm gut sutures are set in the spongy tissue to hold the transplant in position over the underlying corpus spongiosum. There is considerable liability of hematoma forming at the site of this operation, which distinctly limits its usefulness.

Roentgen and Radium Therapy.—Roentgen and radium therapy have been tried in a number of cases, but reports on the efficacy of radiological treatment vary greatly. Thus Galewsky and Weiser[26] claim that of 12 patients, 6 were completely cured, 5 improved, and only 1 received no benefit, but Waters and Colston,[79] after most careful trials in 3 cases, declare that roentgenization, even when very intensive, has apparently no temporary and certainly no permanent, effect on fibro-sclerosis of the penis. From the extensive review given by Sonntag,[66] one would judge that surgery will be most likely to prove satisfactory, but the condition is at best, an extremely difficult one to handle, and the most optimistic operator should be very guarded in making his prognosis.

Granuloma Inguinale.—Commonly termed a tropical disease, granuloma inguinale is now recognized as being endemic among negroes in certain parts of the United States, and as occurring sporadically among Caucasians resident in any geographical location. It was first described by the British physicians practicing in Guiana, Conyers and Daniels, in 1896. About 75 cases have been reported in this country,[25] and it was recently stated that there is not the slightest doubt that this supposedly tropical disease has been endemic in the vicinity of Philadelphia for the past fifty years at least. As this assertion may well hold true for other of our large cities, the ability to recognize this lesion will be of decided advantage to anyone interested in the treatment of the penis or other parts of the external genitals.

Etiology.—The essential etiological factor in granuloma inguinale is the intracellular organism discovered by Donovan in 1905, and constantly found in the lesions. This organism is a capsulated bacillus of the *Bacillus mucosa capsulatus* Friedländer group.[77]

Symptoms.—The typical lesion is a bright red, exuberant overgrowth of granulation tissue.[57] Beginning as a small moist papule, ulceration soon takes place, the surrounding tissue being invaded and destroyed. Exudate at first is scanty, being of a mucoid character

and not offensive, being easily wiped away so as to leave a clean red bleeding surface, having very much the appearance of an area of healthy granulation tissue like that of a large surgical wound. It is usually painless except under pressure, though there is often most intense itching and burning. When infection sets in the picture quickly changes. The lesions then emit a most offensive odor which is considered by some observers to be pathognomonic, and large lesions may become bulbous simulating condylomata acuminata, with large rounded heads of new growths, the heads oftentimes with pearly white surfaces of epithelization and deep crypts with raw granulomatous surfaces.

Location.—As the name indicates, this lesion is most commonly found upon the groin, spreading both upward and downward, frequently involving the perineum, and in the male usually extending to the penis, presenting "a most destructive picture with a gradual erosion of the glans and even the shaft of the penis." Situated upon the glans it is more exuberant and cauliflower-like, so that it has even been taken for carcinoma, at least one patient having been submitted to amputation under this wrong interpretation. When the lesion is situated on the glans the part is much distorted. The granulations are very coarse, usually concealing the meatus and sometimes extending into the urethra, but only for a very short distance. When the lesion becomes annular the formation of fibrous tissue beneath the urethra, with its resulting contracture, may cause typical chordee, or a troublesome stricture.

The patient will frequently give a history of venereal disease, and usually mention a previous trauma, or an infection, especially bubo, the ulceration occurring either after the infection has cleared up, or dating its progress from the time of the primary infection for which ordinary treatment had proved inadequate.[14] Circumcision has frequently preceded the appearance of the lesion. Syphilis may often be a coincident affection, but the idea that granuloma is the result of luetic infection is erroneous. Intensive and persistent treatment with arsphenamine and mercury will have no effect upon these lesions, and although the *Spirochæta pallida* has been found in them, such discoveries are the exception and not the rule, which would be essential to the proof of a syphilitic origin of the disease.

Differential Diagnosis.—There are several conditions which may cause confusion in establishing a diagnosis of granuloma inguinale. The ordinary condyloma of syphilis may simulate the condylomatous type; elephantiasis vulvæ of the syphilitic type may assume the appearance of the lymphatic stasis which is sometimes seen in granuloma inguinale.[29] The possibility of confusion with malignancy has already been mentioned. Tuberculosis and chancroid must also be ruled out, and though this is not ordinarily difficult, at times it may prove very confusing. The typical history, the long duration, finding the Donovan bodies in smears from the lesion, and the typical pathology dis-

played by the disease establish the diagnosis. The development is more slow than that due to tertiary syphilis, and more rapid than that of tuberculosis. As the granulations appear to be more exuberant when the lesion is upon the glans, it is here that it is most likely to be confused with carcinoma. It is easily differentiated from chancroid by the sclerosing everted rolled-out edges, in contrast to the undermined edge of chancroid, with negative inguinal glands. Any patient presenting a chronic sclerosing, serpiginous ulceration of a granulous type, on or near the external genitals, should be thoroughly examined for evidence of granuloma inguinale.

Treatment.—It has been found that local applications, salves, escharotics and antiseptics, are of absolutely no avail; vaccine therapy has regularly failed; recurrence is almost sure to take place after excision, and arsenic has proved of no curative value. Some clinicians have reported good results from the use of roentgen-ray, which brings about a slow cicatrization, but because of the dangers associated with its use, it has been possible to apply it only once every three weeks, therefore requiring on an average from twelve to eighteen months to establish healing. Even with the roentgen-ray, hospital experience in the years past has been disappointing, and probably at least 50 per cent of the cases returned with recurrences.

Dr. John Abels' Antimony Treatment.[1]—The specific treatment which seems now to be established on an unquestionable basis is tartar emetic (antimony and potassium tartrate) intravenously administered.[44] The solution is prepared by dissolving 5 gm. of antimony and potassium tartrate in 500 cc. of distilled water. This is passed through a Berkefeld filter until it is sterile on culture, and 0.5 cc. of hydrochloric acid added to prevent precipitation. A 1 per cent solution may be given intravenously in amounts as large as 20 cc. without reaction, save in very exceptional cases. The practice at Bellevue Hospital (New York) is to begin with about 2 cc. of the tartar emetic solution diluted with 8 cc. of sterile distilled water; the injections being given intravenously three times a week, 1 cc. more of the antimony solution and 1 cc. less of the water being used at each treatment until the full strength (1 per cent) is given. The treatment usually covers six to eight weeks, and it is a wise precaution to give about a dozen more injections when the cure is apparently complete. No recurrences have taken place when this additional medication was given, and where after-treatment was neglected, or entirely omitted, recurrence has not infrequently occurred.

ULCERS OF THE PENIS.

Ducrey Bacillus ("Soft Chancre").—Chancroid has been legally defined as a clinical condition doubtfully correlated with the presence of a certain specific organism—Ducrey's bacillus. It is usually diagnosed on clinical grounds, *but only after* the exclusion of syphilis by

appropriate tests.[15] It is a venereal ulcer of specific origin, contagious and self-inoculating, and, except in rare instances, the primary lesion is localized upon the external genitals, the coronary sulcus in the male and around the introitus in the female.

Differentiation from Syphilitic Chancre.— For years, one might almost say centuries, great difficulty has been experienced in distinguishing between the different venereal affections, and this confusion has been increased by the resemblance in nomenclature which has hopelessly befogged the lay mind, and frequently led members of the medical profession astray. Still further, the fact that the separate affections—that due to the bacillus of Ducrey and that caused by the *Spirochætæ pallida*—may be present simultaneously in the same individual, makes a clear distinction even harder to reach.

An extended discussion of differential diagnosis belongs to the study of venereal diseases and cannot properly find a place here. To the urological surgeon its chief interest lies in the *history*, on which he may perhaps be obliged to base his decisions as to treatment of other and subsequent affections, and in selecting the best method of curing the genital ulcer presented for his ministrations.

The prepuce is more often the seat of venereal lesions than any other part of the penis, and if the prepuce be long, even sores which do not appear on the surface can be palpated through it in cases where retraction is not possible. Harrison[31] says that a dull livid-red or bluish tint upon a prepuce which is swollen and often somewhat scaly, is particularly characteristic of the presence of a syphilitic sore somewhere near, and that such a prepuce will feel tough and "India-rubbery." The entire foreskin may show this indurated edema, even occasionally spreading upon the scrotum, and it is distinguishable from the edema sometimes seen with gonorrhea or chancroid by its color, which is duller and more livid, and by its toughness, as in affections which are not luetic, the edema is much softer. A primary chancre beneath the prepuce upon palpation will give a characteristic rampart-like edge, as if the ulcer were a hard foreign body.

When the ulcer is on the outside, if it is a chancroid it will show the edge characteristic to it which is often irregular with salients thrust out into the surrounding area; it arises abruptly from the normal side for about a millimeter, and is undermined on the ulcer side. The base is usually pitted, or may be covered with a diphtheroid membrane.

A luetic ulcer on the other hand, is always more matted together and less flexible than a chancroid would be; there is usually the areola at the margin of the syphilitic erosion, which is crusted and generally level with the edge. The edge does not rise abruptly from the surrounding skin, but slopes very gently away into the adjacent parts, and the contour is round or oval.

The final test is, of course, that of the bacteriologist. *Spirochætæ pallida* will be demonstrable in a syphilitic ulcer, but unfortunately the presence of Ducrey's bacillus is not so readily determined. Moore,[50]

working in the Venereal Disease Service of the American Expeditionary Forces, was able to demonstrate this organism in smears but 20 times in 81 cases that were clinically chancroid, while of 55 blood agar cultures, only 5 were positive. Teague and Deibert[73] found however, that though great care is necessary to obtain a good growth of the Ducrey bacillus on blood agar plates, it is possible to do it, and by using clotted rabbit's blood for their primary cultures from the ulcers, and inoculating blood agar plates from the clotted blood tubes after twenty-four-hours' incubation, they obtained pure cultures. Their criteria for the routine bacteriological identification of the Ducrey bacillus are: (1) It is a Gram-negative bacillus growing in characteristic long chains and tangles in clotted rabbit's blood; (2) it forms on blood agar characteristic colonies that readily glide over the surface of the medium; (3) it does not grow on any ordinary laboratory cultural medium with the exception of blood agar.

Clinical Varieties.—Clinical classification of four varieties of chancroidal ulcer has been made:[59]

1. *Ulcus molle*, the ordinary ulcer, with characteristic "punched-out" appearance and edges sharply differentiated and often undermined.

2. *Ulcus molle miliare* which begins as a small papule, but rapidly becomes a pustule with a deep crater-like ulcer as the center. This type is most frequently seen in the male just posterior to the mucocutaneous junction of the prepuce, and in the female about the labia majora and the perineum.

3. *Ulcus molle elevatum*, the sore most frequently confused with indurated chancre. Its incubation period is from nine to twenty-one days. The lesion is slightly raised above a mildly infiltrated base, the edges are not undermined, and it shows little tendency to spread. It is persistent and refractory to ordinary treatment.

4. *Ulcus molle phagedenicum*, the most severe and resistant form, occurs as a complication of both chancroid and syphilis, spreading rapidly, and capable of destroying part or even all of the penis, if allowed to progress unchecked.

Mixed Infections.—So long as your patient has chancroid you may never be sure that he has not chancre. This rule, says Keyes, is without exception. The positive demonstration of syphilis is, of course, conclusive, but even when this is not forthcoming, the suspicion must still remain.

Treatment.—If seen early, most chancroids can be cured by rigid attention to cleanliness, and the application of an antiseptic dusting powder or wash. Protection from friction is of the first importance. For those patients who present themselves for attention promptly, cauterization with nitric acid may serve excellently, but this is only when the physician can be sure that he has reached the bottom of each ulcer and destroyed every particle of infected tissue; half-way measures are worse than useless.

In the United States Navy, where the medical attendant is able to control his patients and keep them under close surveillance, the tincture of myrrh and sun methods have been used with success.[34] The first amounts to little more than perfect cleanliness, protection and immobility of the parts affected. The cleansed penis is dressed with an 8 to 1 tincture of myrrh and water solution, well protected and kept continually moist. If the edema and inflammation are marked, the penis is immersed for one-half hour in hot magnesium sulphate or boric acid solution, at frequent intervals.

In the simple type of ulcer—ulcus molle—astonishingly rapid improvement followed three daily cleansings with green soap and water with subsequent exposure to the sun, care being used not to continue the exposure to the point where it causes a dermatitis. Such measures are, however, impossible in clinic practice, where chancroid is most often seen.

The application of argyrol crystals dusted daily upon the ulcer is highly regarded by some authorities; zinc ionization also has its advocates. Several years ago[39] the use of the high frequency current was much lauded.[35] The success of this method, as that of any other way of dealing with chancroid is, according to Robbins and Seabury, dependent on careful thorough work. There is more danger of too little cauterization than of too much, and thorough cleansing at the time the sore is destroyed must not be forgotten. Again, the after-care, especially with ulcus molle outside the preputial, and with ulcus molle miliare, is of the utmost importance. If one fails to carry the electrode to the bottom of the cavernous ulcer, then one is lost. It heals over the surface, and in two or three days breaks out anew, larger and deeper than before.

Technic.—After proper cleansing of the affected area and the cocainization of each ulcer, a 25 per cent solution of copper sulphate in distilled water is applied. A fine-pointed vacuum electrode conveys the short high-frequency spark directly to the lesion, the application lasting from one to three minutes depending on the extent of the ulceration. All fissures and undermined edges should be thoroughly cauterized, and the current should not be turned off until every crack and crevice has been thoroughly treated and the surface of the sore is changed to a dark greenish-gray. Further applications of 10 per cent copper sulphate, or a 5 per cent silver nitrate solution may be needed, or even occasionally, a repetition of the original electrocauterization, but if the treatment is thorough at the outset, nothing more should be necessary, save the application of some antiseptic dusting powder, and protection with a moist dressing until healing occurs.

Bubo. -Infection with Ducrey's bacillus is very often complicated by a suppurative adenitis of the inguinal nodes. The inflammation develops abscess formation which eventually breaks down the tissues and works its way to the surface, emerging through the skin as a

chancroid of the groin. This frequently occurs just when the original penile lesion appears to have run its course, and is practically healed.

Treatment.—The treatment advocated by Keyes is rest in bed, puncture of the points of suppuration with a bistoury, evacuation of the pus and injection of the cavities with a 10 per cent emulsion of iodoform in vaseline, the injection to be repeated every second day until the lesions heal. Harrison paints the affected area with iodine and inserts a needle attached to a 10 cc. syringe, running it into the center of the abscess cavity, in a direction almost parallel to the groin. Only healthy-looking skin should be punctured; if a red, thin and shiny part is selected, the bubo contents will leak through the puncture after the needle has been removed. The abscess cavity is emptied of its contents by aspiration, following which a sterile syringe is filled with a 1 to 20 tincture of iodine solution, or a silver salt solution, which is injected into the cavity. This is aspirated in its turn, and the cavity refilled with 1 or 2 cc. of the solution, the puncture hole sealed with collodion, and a dressing applied. This operation may have to be repeated, and if it fails altogether, a small vertical slit must be made at the lowest point of the bubo, the pus evacuated and a drainage tube inserted. Harrison also advocates the use of autogenous vaccine.

Luetic Ulcer.—The appearance of the typical syphilitic chancre is so well known and universally recognized as to make a description of it in a work of this kind, almost superfluous. More than one-half of the syphilitic ulcers seen upon the penis are of the *erosive* type; flat, usually surrounded by a ring of slightly indurated tissue, the eroded surface appearing as smooth as if it had been polished, and discharging a small amount of sero-purulent fluid.

Hunterian Chancre.—The Hunterian chancre is a true ulcer, with sloping edges and a granulating base, exuding a discharge which is usually blood tinged. When first inspected there is usually a gray-brown crust covering the lesion, removal of which will show the base covered with reddish granulations. Though syphilitic ulcers are painless, the Hunterian type are often very tender to pressure, especially if they lie at the junction of penis and scrotum.

Dark-field Examination should always be carried out before any therapy is applied to such an ulcer, and the diagnosis of syphilis once established, treatment should be along the lines laid down for the efficient handling of that disease.

Tuberculous Ulcer.—There is very little to be found in literature concerning tuberculous infection of the penis. In the early years of the present century considerable attention was given to this subject by French urologists, but in France as elsewhere, it has remained a very uncommon lesion. Chetwood makes no mention of it in the latest edition of his text-book, and Keyes states that he has seen but 3 or 4 cases in a ten-year period. Warren remarks that tuberculosis of the penis may be acquired by coitus with a woman suffering from genital tuberculosis, or more frequently in the case of infants who have under-

gone ritual circumcision, by infection from the sputum of a tubercular [illegible] who has accomplished hemostasis by sucking the wound caused by excision of the foreskin. The penis may also be secondarily infected by tubercle bacilli originating in the kidney and bladder.

The ulcer is very intractable, irregular in shape, its base much indurated and its edges everted. Its general appearance is suggestive of malignancy, and for this reason differential diagnosis is very important. There is also chance of confusion with syphilitic gumma, but the tubercular ulcer displays less tendency to slough, and, except in the cases of circumcised infants, is of extremely slow development. Bacteriological examination will usually make the diagnosis clear.

FIG. 28.—Hunterian or hard chancre stands out like a button under the skin, as is well shown in the accompanying picture.

Treatment.—Treatment is not very satisfactory, and in those cases due to ritual circumcision, practically never successful. Excision of the diseased tissue has appeared to effect a cure in a few of the cases reported.

MALIGNANCY OF THE PENIS.

Sarcoma.—Primary sarcoma of the penis must be regarded as a clinical rarity. Joelson[88] who reviewed the literature very recently, found records of but 35 cases of sarcoma and endothelioma, 6 of which he does not regard as fully authenticated. He adds a very thorough report of a fibrosarcoma of the penis occurring in his own practice.

Like most other sarcomata, those found upon the penis are of a very malignant type. Spindle-cell or mixed-cell sarcomata appear to be less malignant than the endotheliomata or the round-cell type, but only 25 per cent of those on record showed this relatively low grade of malignancy.

Differential Diagnosis.—Differential diagnosis is often difficult as the growth is readily confused with urethral carcinoma, indeed, it is very probable that the apparent rarity of penile sarcoma may be due to failure to make a correct diagnosis in those cases not submitted to pathological study. In the cases collected by Joelson, the great majority occurred in men of the "cancer age," but 4 occurred in younger adults, 1 in a boy aged eight years and 2 in infants. Age, therefore, would not seem to offer much aid in diagnosis. The most common subjective symptoms were pain in the penis or perineum, dysuria, and occasionally, acute retention of urine. The majority of the cases of endothelioma had priapism with an enlarged penis, as if in semi-erection.

Metastasis to the inguinal glands appears very early, the original growth, in most of the reported cases, returning very soon after removal and developing with a rapidly fatal termination. Joelson's patient himself first cut off with a pair of scissors, "a small wart-like growth on the left side of the glans penis." Sixteen months later, it reappeared as a "small reddish nodule" which rapidly grew large, and after three months was removed by a physician. Again recurring and quickly attaining its former size, a biopsy was made by another physician, the growth was at last recognized as sarcoma, and removed, together with the enlarged inguinal glands, by Cunningham's procedure.[20] Eight months after there was no evidence of recurrence or metastasis discoverable by a thorough roentgen-raying of the entire body. Though we are not justified in generalizing from this single instance, it certainly suggests that even at a late date careful and thorough surgery may be highly effective.

Carcinoma: Epithelioma.—Carcinoma, usually epithelial, is a relatively common neoplasm upon the penis, being usually estimated at about 2 per cent of all malignant neoplastic growths. Very early in the history of medicine we find descriptions of the lesion, and of attempts to extirpate it, and the literature at present available upon the subject is very extended. The most complete study which has come to our attention is that of Barney[3] made, largely from the records of the Massachusetts General Hospital, in 1907, and the majority of writers during the past two decades have drawn upon his work for statistics. Peters,[55] a German surgeon has recently (1921) made a detailed investigation of 25 cases, many of which have been under observation for a number of years after operation, which makes this study particularly valuable in regard to prognosis and final results.

Etiology.—Etiology as in other forms of carcinoma, is obscure. A number of observers have noted that penile carcinoma occurred where the patient's wife had suffered antecedently from cervical carcinoma, but the authenticated instances are too few to rule out accidental coincidence. Sutherland[71] who studied the incidence of malignant disease in a certain section of India, noted that while the hospital admissions for other malignancy were about evenly divided between

Mohammedans and Hindoos, in the case of carcinoma, Hindoo admissions greatly exceeded those of Mohammedans, as in a total of 792 malignancies, 72 were cases of carcinoma of the penis, all of which occurred in Hindoos. This, he remarks, is an affection from which Mohammedans (who practice circumcision) very rarely suffer. In Barney's 100 cases not a single circumcised Jew was found, and Cunningham points out that numerous writers have called attention

Fig. 29.—Small carcinoma of penis with great involvement of inguinal glands. The left group of glands has broken down and presents a fungus-like growth in the groin.

to the immunity of the Jew from this disease, which is suggestive at least, that early circumcision may have some influence against the development of this condition. Barringer and Dean[5] in reporting 36 cases treated at the Memorial Hospital from 1919 to 1923, state that no Jews appear in this series, and further remark that it is extremely rare to encounter this lesion in Hebrews.

These observations point strongly to phimosis as an etiological factor,

and no one can fail to feel the force of the statement. When, as the result of a prepuce difficult or impossible to retract, there is added the irritation of retained inspissated smegna, the circumstances are ideal for the development of penis cancer.[6]

Trauma may account for a certain percentage of cases. Many patients date the beginning of the growth to a late circumcision for

FIG. 30.—Extensive carcinoma of penis with moderate involvement of inguinal glands on both sides.

the relief of phimosis. In one of Schreiner and Kress's[64] patients there was a history of a warty growth appearing in the line of incision after operation for phimosis, which in the course of a year was definitely shown to be a malignant tumor. But we must also consider the possibility of malignancy having existed before the surgical intervention, which merely served to accentuate the process.

Syphilis is probably an etiological factor in some cases. Cunningham saw a carcinoma develop at the site of a chancre which had been healed but a few months, and many other writers have noted a similar sequence. Venereal warts may very well be the forerunners of cancer, and many agree that all papillary growths on the glans penis are potentially malignant.

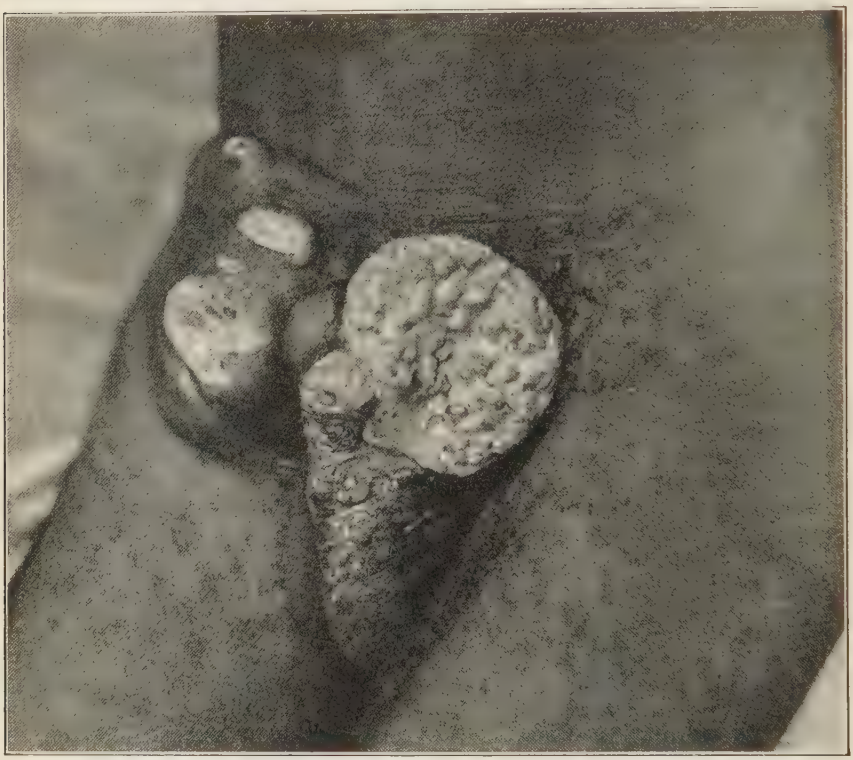

FIG. 31.—Advanced stage of carcinoma of penis involving inguinal glands on both sides.

Location.—By far the greater number of penile carcinomata appear upon the glans, but they may also develop primarily on the reflection of the mucous membrane from behind the corona to the prepuce; they are seldom found in the fossa navicularis. Metastases appear very early; in Barney's cases the condition of the glands was mentioned in but 66, but in three-quarters of these metastasis was present at the initial examination.

Types.—The neoplasm may be of either the papillary, cauliflower, type, more likely to be seen on the glans, or the infiltrating indurated-ulcer type, which is commonly found upon the prepuce. The histological structure of epithelioma of the penis shows mucous pearls and hornifications, which are also well marked in the metastases.

PLATE III

Longitudinal Section Made by the Frozen Section Method of Christeller Through the Penis of a Man Who was Afflicted with Carcinoma of the Penis. This is the Cauliflower Type of Epithelioma.

a, Corpus cavernosum penis; *b*, Buck's fascia (tunica fibrosa); *c*, glans penis; *d*, urethra; *e*, external epithelium of prepuce, unaffected; *f*, internal epithelial lining of prepuce, unaffected; *g*, carcinomatous papillary mass; *h*, small patch of papillomatous tissue showing destructive growth into cavernous body; *i*, papillary masses which show evidence of breaking through the epithelial lining; *k*, carcinomatous mass giving the growth its cauliflower appearance. Perforation through the skin.

Prognosis. –The prognosis of penile carcinoma is slightly better than that of sarcoma, and it is noticeable that the most recent publications contain reports of patients who have survived operation for considerable periods. A few months ago a man who was operated in November, 1909, being then aged fifty years, was reported as in good health with a satisfactory urinary function and no signs of recurrence, nearly fourteen years after operation.[65] One patient treated by radium at the Memorial Hospital (New York), whose entire glans was involved, has survived forty-three months without recurrence. Peters reported 14 patients who were still in good health thirteen years after operation. In Barney's series 3 patients died four, eight and nine years after operation from other causes, and the effects of senility. As the majority of these patients do not develop the penile neoplasm until late in life, this factor of senility must always be reckoned with, in considering the success of the surgical intervention.

OPERATIVE SURGERY OF THE PENIS.

Anesthesia.--The use of a general anesthetic when performing a surgical operation upon the penis, is becoming increasingly less common. It has been found that practically all surgery upon this organ can be carried out under local anesthesia, or by the sacral or parasacral methods, with exactly as much ease for the surgeon, and infinitely less disturbance to the patient. In many cases this method makes operation possible for those who, for one reason or another, cannot safely be placed under the influence of a general anesthetic.

Sacral Anesthesia.—The method employed by the authors in interventions upon the penis and other procedures in this region—which will be discussed in detail in their proper sequence—is substantially that described by Parker Syms,[72] who made use of it principally for work in the rectum and about the anus, although he also applied it in operations upon the prostate and scrotum, and in doing circumcision. Details of the method will be given in connection with prostatectomy, in which it finds its widest application. In operations upon the penis, from 30 to 50 cc. of freshly prepared 1 per cent procain solution is injected into the sacral canal, anesthesia taking place on the posterior surfaces of the scrotum and penis in about ten minutes, although we always delay a full twenty minutes before beginning to operate. In addition, injection of procain solution is made in the region of the dorsal nerve at the penopubic junction.

Local Anesthesia. –When a simple dorsal incision of the prepuce for phimosis is to be done, only the line of incision needs to be infiltrated, which may be done by the injection of 1 or 2 cc. of 1 per cent procain solution, passing a very fine needle between the skin and mucous membrane, upward over the coronary sulcus. A point on the dorsum of the penis will sometimes be found to be a more convenient site of injec-

tion. Under these circumstances the needle must be passed under the skin as far as the edges of the prepuce.

If it is desired to anesthetize the entire prepuce before operating for phimosis, the foreskin should be drawn tensely over the glans, and tied with tape to retain it in this position. Injection is then made into the coronary sulcus, removing the tape only when the part is completely anesthetized. If the operation is for the relief of paraphimosis, one circular injection will have to be made into the coronary sulcus, and a second one above the point where constriction exists. When injecting suprarenin into the periphery of the penis it must be borne in mind that the prepuce is supplied by end-arteries, and tissue damage may result if the suprarenin causes too great contraction of all these vessels, for the tissues will be unable to dispose of the injected anesthetic. Any such accident can be avoided by never using more than 1 or 1.5 cc. of a 1-part solution of procain in injecting the penis. A further precaution is to avoid circular peripheral injection altogether, and in phimosis operations to rely entirely upon the effect of injections at the base of the penis.

Complete Local Anesthesia of the Penis.—Two points of injection are made, one to the right and one to the left of the base of the penis, at a point where the spermatic cord crosses the horizontal ramus of the pubis. From these two points, with the penis drawn out and held in this position, a 0.5 per cent procain solution is injected. The needle is then passed as deep as the corpora cavernosa, circuminjecting them at the point where they emerge from the angle of the symphysis at the point of union with the penile shaft. From below the needle penetrates the scrotum; above, it reaches the suspensory ligament of the penis. In fat subjects long needles must be used. A second injection just under the skin is then made, corresponding to the dark line shown in Fig. 33. In an adult with a moderate amount of fat, about 75 cc. of 0.5 per cent solution are required, a proportionately smaller amount being used in children. The entire penis, skin, prepuce, glans, the pendulous portion of the urethra, and the corpora cavernosa, distal to the pubes, are rendered insensitive. This method is suitable for all operations in the parts named —for example in amputation of the penis, plastic operations upon the urethra, urethral fistula, as well as for phimosis and paraphimosis.[13]

Circumcision.—It has usually been found more satisfactory to give a general anesthetic to children undergoing circumcision; in adults, regional or local anesthesia is to be preferred.

Under suitable aseptic precautions, the foreskin is retracted until its orifice is tensely stretched. It may be clamped obliquely by a pair of circumcision forceps as recommended by Chetwood, or three pairs of fine-toothed forceps may be placed on the tense edge, two close together on each side the median line dorsally, and one at the middle line ventrally, the fore-skin being then raised and separated from the glans by a director. This second method follows the practice of Thom-

son. The field is kept relatively free from blood by placing a constrictor about the shaft of the penis, close to the pubis. If a single forceps is

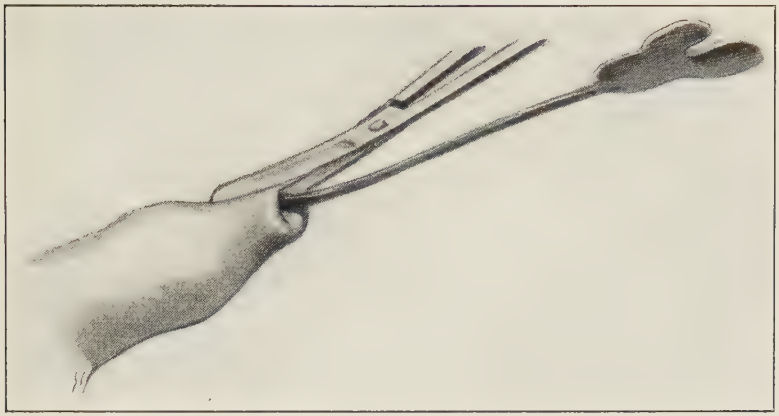

FIG. 32.—This picture shows a dorsal slit being made with the grooved director as a guide. This is the first step in doing a circumcision.

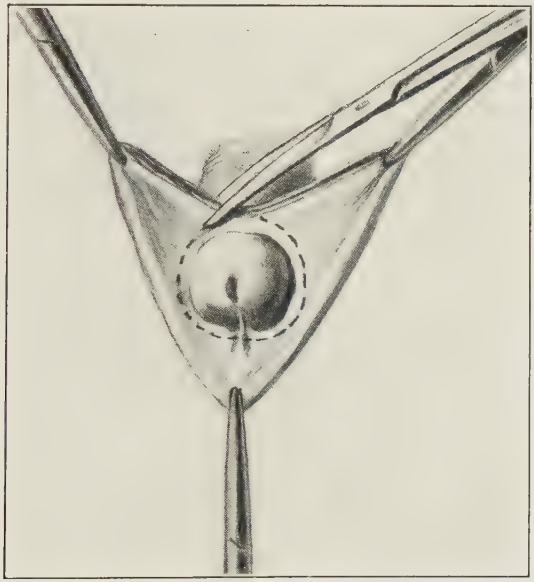

FIG. 33.—The incision in the dorsum of the prepuce is then continued around the corona, about 1 cm. from the sulcus.

used the incision should be oblique and not circular, the prepuce beyond the point where the forceps is located being cut away, and the mucosa which still covers the glans slit up on the dorsal aspect to within a

¼-inch of its attachment, in infants it may be as close as an ⅛-inch, both sides of the frenum being evenly trimmed off.

Three-clamp Method.—If three clamps are used, the prepuce is slit with scissors up the middle line of the dorsum as far as the postcoronal sulcus, so that a pair of forceps holds the edge of one of the flaps thus formed; these flaps being well stripped from both glans and corona. A second incision is made from the end of the initial one, which is carried around one flap of foreskin, so that only a narrow ridge of mucosa remains below the corona. This flap being cut away leaving the lower pair of forceps attached, the incision is carried around the penis, thus cutting off the section of prepuce to which the other two forceps are attached.

The foreskin removed, the constrictor at the base of the penis is loosened and the bleeding-points noted. There are usually four of these; one upon the dorsum, two at the sides and one at the frenum, and in some cases it will be necessary to ligate them in order to prevent dangerous hemorrhage.

FIG. 34

FIG. 35

FIG. 34.—After the bleeding points are clamped and ligated, the cut edges are approximated by interrupted sutures beginning at the frenum. The second stitch is taken at a point exactly opposite from the frenum.

FIG. 35.—The cut edges of the prepuce are then approximated with as many catgut sutures as necessary to accomplish this purpose.

Sutures.—Some surgeons use no sutures whatever. Others sew the skin and mucous layer together at the base of the glans. No dressing is necessary for young children, other than a gauze pad to protect the operated surface from contact with the clothing; adults should be supplied with a suitable dressing, which should completely encircle the penis but be so arranged that it will not become soiled during micturition. The parts should at all times be kept dry and clean, and some antiseptic dusting powder be freely employed.

Reduction of Paraphimosis.—Paraphimosis may be due to a congenitally narrow preputial opening, or it may be impossible to retract the foreskin because of inflammation due to balanitis or one of the

venereal diseases. Such a stricture may be so tight as to induce gangrene unless promptly relieved.

Reduction can usually be accomplished without cutting or the use of anesthetics, but in severe cases, both are likely to be necessary. Suppression of the edema always in evidence, is also an absolute prerequisite to successful reduction. By gentle but persistent squeezing in front of the point of stricture, most of the edema may be forced back along the penile shaft. The operator should then take a firm hold with a hand on each side of the penis behind the point of stricture; the second fingers of either hand should support the shaft below, the first fingers pass behind the stricture above, while the thumbs compress the glans on both sides, at the same time endeavoring to push the prepuce forward; the idea being, not so much to force the glans backward, as to push the foreskin forward and over it. As Thomson has said, the traction is more important than the pressure.

If this effort fails, the strictured portion and the edematous folds of tissue behind it will have to be incised under local anesthesia. Thereafter, treatment must be carried out as for incised wounds, the parts being kept scrupulously clean and supported until healing is complete. When reduction can be accomplished without incision, irrigation with a mild antiseptic and the use of a suspensory for a few days is usually all that is necessary in the way of after-treatment.

Amputation of the Penis.—In epithelioma the primary growth is most commonly upon the distal portion of the penis. Thence, early metastasis takes place through the lymphatic channels of the penile shaft until it attains the superficial inguinal glands; from these the disease extends to the deeper glands of the inguinal region, finally passing under Poupart's ligament and attaining the pelvic iliac nodes. If the neoplasm reaches the urethra early in its development, extension may be over the symphysis directly to the glands of the iliac region. Operation must therefore, take into consideration not only extirpation of the neoplasm itself with that part of the lymphatic system directly involved, but also the destruction of the secondary lymph channels for which the affected lymph glands furnish an outlet.

The procedure most generally removes not only the penis, but the lymphatic glands and their channels without breaking their continuity, thus avoiding dissemination of the cancer cells.[20]

With the patient in the lithotomy position and a steel sound in the urethra, an incision is made on each side from the symphysis downward to the root of the penis, the two incisions meeting, so that the penis is completely encircled. Below, the incision is carried downward along the median raphé until it reaches the perineum. The scrotum is bisected, but the tunica vaginalis is not broached, the testicles being separated by blunt dissection which is carried down to the corpus spongiosum and continued until the urethra is free as far back as the anterior leaf of the triangular ligament. The urethra is severed about $\frac{3}{4}$-inch in front of the bulb, having first been secured by an artery

clamp. The dorsal vessels are ligated and the suspensory ligament of the penis divided. The dissection is carried down to the point of attachment of the pubic rami, and the crura being held by clamps close to the bone, are then bisected. The arteries can be secured by placing a

FIG. 36.—Wounds in groins and below symphysis following removal of inguinal glands and penis for carcinoma. This patient is now alive, more than six years after operation, with no sign of recurrence.

ligature around the crura. The lower urethra and the crura can now be removed, while the divided urethra is split and stitched with catgut to the lower angle of the wound.

FIG. 37.—Perineal transplantation of urethra following total extirpation of penis for carcinoma.

The patient being shifted to the dorsal position, the excision is extended upward, parallel with Poupart's ligament, and diverging outward to the anterior-superior iliac spine. The inguinal glands and the attached fat are freed by blunt dissection and removed in a single mass, together with the penis, the dissection being carried down to the external oblique muscle. If the mass does not continue from the superficial to the deep glands, it may be necessary to divide the fascia lata, so that these deep glands can be dissected free from the femoral vessels. A catheter is run through the urethra at its attachment to the lower part of the perineal wound, and passed into the bladder. If a soft rubber catheter is employed it must be stitched to the skin, to be removed three or four days later,[74] at which time the patient is usually able to urinate without mechanical aid. An important point in closing

FIG. 38.—Carcinoma of penis after removal from case mentioned above. The remains of the prepuce may be noted at one place.

the wound is to suture the scrotum in such a manner that it will be lifted out of the way of the urinary stream.[20] Most operators prefer to remove the lymphatic glands before excising the penis, as it is thought that in this way there may be less chance for dissemination of cancer cells.

Plastic Surgery of the Penis.—All forms of plastic surgery received a marked impetus through the experiences of the World War, and in urological surgery the particular aspect which is of most interest is that of repair of injury to the male organ of copulation. What may be done for patients whose external genitalia have been largely destroyed has been mentioned on page 138. If, through trauma the penis has been denuded of skin, and is then allowed to heal by granulation and the formation of scar tissue, erection will thereafter be wholly impossible. If the injury has been so severe that all the skin has been

destroyed, cicatricial contraction will be so great as to render urination extremely difficult, the glans being often so retracted as to bend the penis into the shape of a fish-hook, with the meatus facing the abdomen.

FIG. 39.—Carcinoma of penis. Left lateral view of specimen shown above. Cauliflower like mass has entirely obliterated prepuce on this side.

Scrotal Skin Grafts.—The two chief considerations in undertaking plastic work upon the penis are the securing of grafts which will be

flexible enough to permit erection without curvature, and the prevention of infection in an operative field peculiarly exposed to it. Grafts secured from the scrotum are sure to become edematous and thicken immediately after their employment in repair of injury to the penis, but experience has shown that eventually their natural flexibility will be restored.[9] The blood supply to the skin grafts is of extreme importance, for the available skin in this region is so limited that should necrosis occur in the first flap taken, no further material can be obtained and failure will be inevitable. A sufficiently wide base for the flap, warm dressings and great care to prevent constriction by twisting, are necessary. The dartos must not be included in the skin flap as the muscular fibers and connective tissue it contains render it unsuitable for grafting purposes in this particular connection.

Benedict's Method.—A splendid procedure is the method of grafting devised by Benedict of Birmingham, Alabama, which is readily accomplished. A flap is taken from above downward tapering gradually, a size of about $2\frac{1}{2}$ inches long by $1\frac{1}{2}$ inches at the base, having proved the most satisfactory. A longer flap may live, but its survival will depend altogether upon individual peculiarities of the scrotal blood supply of this particular patient, and gives no guarantee against partial sloughing. At least three weeks must be allowed for union to take place before the flaps are cut away from the base, and it has proved wisest to sever them gradually under novocaine anesthesia. Success will attend only the most careful attention to the minutest details, and the most rigid asepsis must be continually maintained. Erections must be prevented by the application of ice compresses and the administration of bromides in large doses—the originator of this procedure also specifies the employment of a male nurse.

NON-SURGICAL TREATMENT OF MALIGNANCY OF THE PENIS.

The treatment of carcinoma of the penis by radium has not as yet been extensively reported, probably because of the fact that this organ offers itself as an especially good site for surgical excision. Compared to the amount of radium work done on malignancy of the bladder, prostate and seminal vesicles, the data relating to the results of radium therapy of the penis are meagre indeed.

Work of Janeway and Barringer.—In 1916 Janeway gave out from the Memorial Hospital in New York reports concerning 7 patients who had received radium treatment for penile carcinoma. In 3 of these cases the disease appeared at one time to have completely retrogressed; 2 patients however, made no improvement; 2 were improving but still under observation, and 1 was lost to knowledge.[36] The work at this hospital has gone steadily forward since this first report was made, and some months ago (1924) a second series of 36 cases of carcinoma of the penis treated by radium was reported. Sixteen of these, after a lapse of time varying from six months to two

years, are apparently free from disease; 11 are dead; 1 result unknown; and the remainder either not improved or still under treatment. In the consideration of this apparently high mortality percentage we must not forget that radium is still regarded in many quarters as a last resort; in carcinoma of the penis especially, it is frequently applied only after all other methods have failed.

Application.—For the papillary carcinoma without induration of its base, and without penetration of the tunic of the glans penis, surface radiation with radium is apparently the method of choice. If there is induration and some penetration of the tunic of the glans, and by slight extension along the penis, implanted radium *may* cure. But if there is extensive involvement of the glans, local amputation, 2.5 cm. beyond the growth, is indicated.

Treatment of the Inguinal Lymph Nodes.—When the nodes cannot be palpated, the accepted procedure is to apply roentgen radiation to the groin, and to keep that region under continual observation; the same procedure is carried out in those cases where the nodes can be palpated but there is reason to believe the enlargement is due only to infection, the primary focus in the penis meanwhile, receiving appropriate treatment. If the lymph-glands are unquestionably carcinomatous, they are radiated, and, where diagnosis is difficult, bilateral dissection is done with radium buried along the lymph-channels, either in the form of bare tubes or screened emanation, the most important area to radiate being the lymph channels around the saphenous opening. When the nodes are thought to be both carcinomatous and infected, the lesion on the penis is dealt with and the source of infection cleared up before the nodes are touched. After dissection has been done, the wound is partially sutured and Carrel-Dakin irrigation employed until granulation takes place.

Value of Radium Treatment in Penile Carcinoma.—Both papillary and infiltrating carcinoma of the penis may be removed by radium, if the tunic covering the glans has not been penetrated, but as stated previously, if penetration of the glans has already occurred before the patient comes under treatment, surgery offers a better prognosis than radium therapy. It is the opinion of those best informed that the most satisfactory results are to be obtained by conservative treatment of the regional lymph nodes with routine roentgen-ray applications in all cases, withholding surgical removal until the glands are definitely proved to be carcinomatous. And it should be especially emphasized that no surgery should be done on the lymph nodes in the presence of pyogenic infection. It is necessary in such a case, to deal first with the source of any such infection, that is, with the penis itself.

A papillary growth on the dorsal aspect of the sulcus above the glans, which had twice recurred after surgical removal, during a period of nine months, was treated by Vaughan of the British Indian Medical Service. After the growth was removed for the third time, two platinum tubes 0.5 mm. thick, each containing 5 mg. of pure radium sul-

phate, were immediately placed in the wound where they were allowed to remain for twenty-five minutes, no further screening being used. Another application was made two days later, and after the lapse of fifteen months there had been no return of the growth. This illustrates the value of radium even in apparently hopeless cases.[76]

Roentgenotherapy of the Penis.—Since the employment of radium has become more generally possible, roentgenological treatment of malignancies such as those occurring upon the penis has been less frequently employed. Yet considerable success has attended the use of roentgen-ray under these conditions, and, as has just been noted, its employment in conjunction with radium treatment offers many advantages. Where radium is not available the patient should certainly be given whatever benefit it is possible for him to obtain from roentgenotherapy. In inoperable conditions where the process has advanced beyond any hope of cure, the patient's sufferings can be mitigated and the comfort of those who surround him can be greatly increased by the use of this form of radiation.

Treatment with Ultra-violet Ray.—In this connection also, should be mentioned the use of the ultra-violet ray. The lesions to which this particular form of therapy are applicable do not, as a rule, occur with frequency upon the penis. Tuberculosis of this organ is, as we have seen, a rare affection, and the more common skin diseases do not occur there. However, a number of favorable reports of such heliotherapeutic applications have been made, and in conditions to which the use of the rays is suited, the prognosis is much improved by their employment.

Another possible application of these rays is as a preparatory measure before roentgen-raying, the theory being that the skin which has been subjected to ultra-violet radiation is rendered much more resistant to the destructive effects of the roentgen-ray. In cases of sarcoma and inoperable conditions generally, such preliminary hardening has proved very effectual in preventing erythema from interrupting the roentgen-ray treatments.[63]

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CHAPTER VI.

THE SCROTUM.

ANATOMY OF THE SCROTUM.

Embryology.—In discussing the embryology of the penis we have already shown that when the fetus has attained an approximate length of 100 mm. a groove is formed to the tip of the glans by the splitting of its solid urethral plate. Later, after this groove is definitely closed, it continues as the urethra until it attains the meatus at the tip of the glans. As at this point in development there takes place a very rapid elongation of the penile organ, an area will soon become evident between the base of the penis and the anus which shows no evidence of pairing. Felix designated this as the *scrotal area* because it is the anlage of the scrotum. Even when the embryo has attained a length of no more than 60 mm., we will find here a median *scrotal swelling* which continues laterally with the paired genital swellings, which are later to form the labia majora of the female. The thick tissue which is found at this time in the medial line of the scrotal area will later on be stretched by the development of the scrotal sac, so that it will form the *septum scroti*. An external median depression is caused by the attachment of this septum, which has been named the *raphé*. Thus it will be seen that although the scrotum itself is a structure which remains single without duplication during the entire life cycle of the individual, its two vaginal sacs receive the testicles through the paired genital swellings when the time arrives for them to descend.

Anatomy.—When the septum scroti has reached its full development and the testicles lie in their permanent positions in the scrotal sacs, the scrotum consists of three layers, separated by connective tissue, the outer or *dartos* composed of unstriped muscle fiber; directly beneath this lies the external spermatic fascia, the middle layer or cremasteric largely composed of striped muscle fiber; this in turn being separated by the internal spermatic fascia and the subperitoneal fascia from the inner layer or *tunica vaginalis*. The integument of the scrotum is often deeply pigmented, and when adult development is attained is sparsely covered with coarse hairs. It contains many glands both sebaceous and sudoriferous, which always show a high degree of development. From either side the sulcus of the raphé, the loose distensible skin lies in a multitude of tiny transverse wrinkles, which can be easily smoothed out when the integument is slightly stretched.

The Dartos.—The dartos is composed of elastic tissue with an intermingling of unstriped muscle fibers, presenting a thin layer of a reddish

tint which, although adherent to the deep surface of the skin, passes in between the two testicles so as to form a separate container for each, and then continues over the penis and perineum. The wrinkles upon the scrotum are due to the prevailing direction of the muscle fibers of the dartos which largely run longitudinally. In a condition of normal health and virility these muscles fibers are always somewhat contracted, and external stimuli, such as cold or emotion, will induce still greater contraction. In age, or when constitutional enfeeblement is present, they will become permanently relaxed.

FIG. 40.—This figure shows a peculiar tubular structure which has developed and persisted in the median raphæ. It begins at a point about the middle of the scrotum and extends to a point just anterior to the anus. A silver wire has been introduced into the tube throughout its entire length.

Certain anatomists describe the dartos as divided into two layers, the upper investing both testicles, while the lower and more resistant one provides each testicle with a separate envelope, this having part in the formation of the scrotal septum. A layer of laminated connective tissue without fat lies within and closely adherent to the dartos, which is called the *external spermatic* or *inter-columnar fascia*. At the external inguinal opening this layer converges with the strong fibrous bands which cross the columns of the *external inguinal ring*. Like the dartos, this fascia is prolonged over the penis and perineum, being continuous

below with the superficial perineal fascia, and above with the superficial fascia which covers the symphysis pubis.

The *cremasteric* or *middle spermatic fascia* covers the cord and testicle with a well-defined fibro-muscular investment, made up of areolar and elastic tissue arranged in a strong double lamina, enclosing longitudinal bundles of striped muscle, the fibers of which extend to the external inguinal ring. Underneath, opposite the lower extremity of the testicle, this middle layer blends with the dartos. Contraction of these muscle fibers takes place under the stimulus of emotion, or when the abdominal muscles are concerned in expiration.

A delicate connective tissue, the *internal spermatic* or *infundibuliform* fascia, together with a laminated prolongation of the subperitoneal tissue which closely invests the elements of the cord and testicle, lies above the tunica vaginalis. The lower of these three structures is of special surgical interest in that it may become the site of fatty tumors of the cord which have occasionally led to a mistaken diagnosis of inguinal hernia. The tunica vaginalis will be described in connection with the anatomy of the testicles (page 210).

Blood Supply, Lymphatics and Nerves.—The external integument and the dartos receive their circulation from branches of the external pudic arteries, as well as from the superficial perineal vessels. The cremasteric and also the intervening fascial layers are supplied by a special branch from the deep epigastric artery. The scrotal veins communicate with the pudic, the long saphenous and the dorsal vein of the penis. The lymphatics have their outlet in the innermost set of inguinal glands. The nerves take their origin in the genito-crural nerve of the lumbar plexus, and the superficial perineal of the sacral plexus.

The anatomy of the scrotum is of special interest because: (1) From close attachment of the dartos to the skin, the skin when traumatized is liable to be inverted, thus making perfect apposition difficult when suturing incisions in this part of the body; (2) in consequence of the loose texture of the cellular tissue lying within the dartos and the abundant vascularity of the scrotum, the bleeding incident to trauma is very free and likely to form large accumulations; (3) on account of this same arrangement edema of the scrotum from comparatively slight causes will be very pronounced, and if septic infection occurs, it spreads quickly and sloughs widely.[36]

ANOMALIES OF THE SCROTUM.

Anomalies of the scrotum are of necessity, closely related to those of the structures closely adjacent to it.

Bilobate Formation.—When development has been arrested union of the lateral halves, along the line of the median raphé, may not take place, the result of which will be the formation of a separate pouch for each testicle. In Eddington's case which was associated with hypo-

spadias, the raphé presented as a median ridge commencing at the root of the penis about 6 mm. behind the urethral opening, and on being traced backward to the scrotum for a distance of 7 mm. from its origin, was found to be formed of two lips with an intervening furrow. This arrangement extended to the anterior end of the perineal portion where it assumed the normal appearance of the median ridge. The

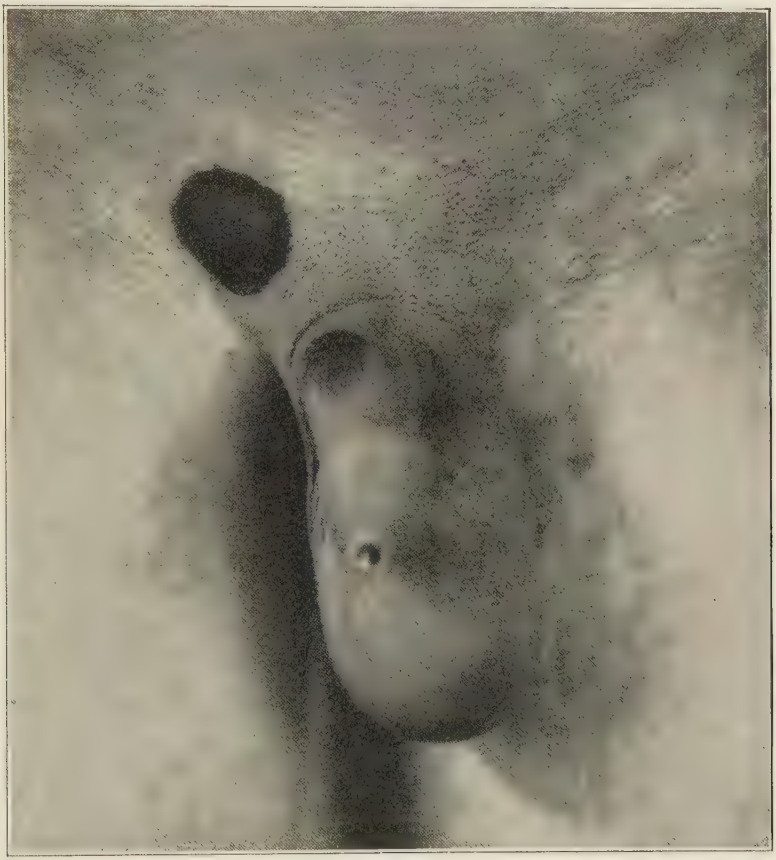

FIG. 41.—The undescended testis is located under the area pointed with iodine. The right side of the scrotum is entirely undeveloped while the left side is quite normal.

bifid appearance of the structure stopped suddenly where it joined the median ridge on the upper and anterior part of the scrotum, the lips appearing to balloon out so that each formed a small but definitely observable swelling.[11]

In individuals presenting this bifid anomaly hypospadias will almost always be present also. An exceptional case was, however, recently reported, wherein the scrotum was completely cleft but no

other malformation was apparent. The patient had reached the age of fifty-four years when, because of the relaxed muscle fibers which made the two scrotal pouches very long and pendulous, he first found his condition annoying. He therefore tied them in a single knot, across the dorsum of the penis. The edema which quickly followed this manipulation made it impossible to untie the knot, and the man came under observation with a gangrenous condition of both sides which made complete castration inevitable.[21]

FIG. 42.—A case of hermaphroditism (male type) showing a divided scrotum which has some resemblance to the labia majora of the female.

Undescended Testicle.—Failure of the testicle to descend causes that part of the scrotum which has not received its normal content to appear shriveled, and often to remain noticeably undeveloped. Other anomalies may exist in conjunction with this condition, as in a case reported not long ago from Canada which showed a small left scrotum containing no testicle but the right side greatly enlarged, while posteriorly there was a palpable mass extending well up into the the inguinal canal. On section this mass proved to be both testicles, together with a fairly well-developed uterus with attached Fallopian tube.[18] When the testicles on both sides fail to descend the appearance of the scrotum will simulate very closely the labia majora of the female, and there may be some difficulty in determining the sex of the

individual. This anomaly constitutes one feature of the condition commonly designated *pseudo-hermaphroditism*

Adhesions.—In the new-born adhesions are sometimes seen binding the penis and scrotum together, a minor anomaly easily amenable to surgical correction.

INJURIES OF THE SCROTUM.

War Wounds.—Many observations upon wounds of the scrotum were made during the World War. These injuries were, as a rule, more extensive than those likely to be encountered in traumatic lesions in civil life, and the surrounding structures were more often involved. Moreover, as they occurred always in young adults in full sexual activity the necessity of conserving the function of the testicles was especially great. Frequently there would be merely a simple contusion of the scrotum giving rise to a hematoma or traumatic orchitis, or an uncomplicated wound with or without a foreign body lodged in its cavity, sometimes accompanied by lesions of the urethra or hernia of the testicle. Wounds of the scrotum received in war are usually recovered from with ease, and this applies to traumatic orchitis *if*—and it is a very large "if"—there is no infectious complication or associated wounds of neighboring structures.[10]

Contusions.—Treatment of contusions of the scrotum is relatively simple. Moist humid dressings applied with slight compression usually suffice to allay the pain and prevent formation of a tumor. When the swelling persists in spite of such treatment it may be taken as an indication of the presence of either a hematoma of the scrotum, or a hematocele of the tunica vaginalis which must be handled in the same manner as these conditions when they appear under other circumstances. The same is true should a hematocele develop, as sometimes happens. While the regenerative properties of scrotal tissue are so great that all small wounds heal with ease, if extensive areas of tissue have been lost, plastic operations will be necessary, according to the methods outlined elsewhere. Foreign bodies should be removed immediately, which is easily done if only the scrotum is involved. If a hernia of the testicle has taken place, reduction should be attempted as soon as possible in order to avoid strangulation with its inevitable sequel, sloughing or gangrene. Cumston says the reduction may be delayed for a few days until the scrotal wound has been properly cleansed, if it appears to be infected, as is usually the case, but at the same time the vitality of the testicle must be carefully watched.

Injuries to the scrotum are decidedly uncommon in civil life, but as has already been noted, its regenerative powers are so remarkable that any uncomplicated lacerations will heal by nature with very little aid from the surgeon. In industrial practice occasionally one meets with the most severe lacerations, even the entire scrotum may be torn away. In one reported case[40] the scrotum was entirely absent,

having been torn away at its junction with the body. The right testis, with the cord, both apparently uninjured, hung from the wound. The left testicle was missing. The skin of the penis had been removed as completely as could have been done by dissection. The skin had separated accurately at the muco-membranous junction of the prepuce, the mucous surface of the latter showing no evidence of injury whatever.

FIG. 43.—The accompanying hematoma of the scrotum and penis was caused by a very slight contusion. Recovery was prompt, complete, and unaccompanied by pain.

Treatment.—In the case just cited an envelope for the testicle was fashioned from skin flaps from the thighs and the penis covered by small skin grafts, also from the thighs, which were applied a few at a time. The result was excellent, even the cosmetic effect being practically normal and sexual function remained unimpaired. The chief points to be remembered are thorough cleansing of the original wound, and the maintenance of antisepsis throughout the healing process, careful examination to discover and stop all sources of hemorrhage, the avoidance of postoperative hematoma being of the utmost importance. If the skin edges are properly sutured, healing by first intention usually takes place, even where the loss of substance has been considerable.

DISEASES OF THE SCROTUM.

Cutaneous Affections.—The scrotum like other areas of cutaneous tissue, is subject to a variety of skin affections which must be treated

in the same way as those occurring in other parts of the body. But as the surface here is unusually delicate and sensitive, many local applications which are of service elsewhere, are here contraindicated.

Scabies.—The itch mite, though evidencing a predilection for the hand and arm, frequently invades the scrotum, and, especially under the conditions surrounding troops in the field, can become remarkably prevalent in this particular location. Scabies is often diagnosed as eczema, because the symptoms of this latter skin affection are sometimes very closely simulated. In any itching dermatitis in the scrotal region a search should at once be instituted for the characteristic burrow, and an attempt made to demonstrate the presence of the acarus or her eggs. These are ordinarily readily detected in the lower social strata where personal cleanliness is not highly prized, but as under war conditions and similar emergencies the clean and the unclean may be equally exposed to attacks of this parasite, the characteristic appearance may be altered by bathing and the use of soap. If the itching is worse at night the suspicion of scabies is much increased.

The actual presence of the acarus does not produce any inflammatory reaction, but scratching and secondary infections change the clinical picture and frequently veil the symptoms, especially in those patients who would be thought unlikely to have come in contact with the infection.

Treatment.—Treatment does not differ in any way from the mode of handling this parasitic invasion on other cutaneous areas except that the extreme sensibility of the scrotal skin must always be taken into account.

Pediculosis. The invasion of pediculi pubis may cover the scrotum with "crabs" and "nits." The nits usually first appear as small shiny spots and bluish maculæ which will be found distributed over the base of the thigh and the adjacent parts. To those who have become familiar with its appearance, it is ordinarily easy to detect the parasite which is attached to the pubic hair by four claws, lying flat upon the skin and adherent to it.

Treatment.—If only a few parasites and nits are present they are most readily eradicated by pulling out the affected hairs; when they are very numerous this will be, of course, too slow and painful, Sabouraud recommends the application of purified xylol. This benzine causes smarting of the skin and the application should not last more than two or three minutes. Though all the parasites and eggs are instantaneously destroyed, there is a risk of slight traumatic dermatitis, but this may be avoided by the immediate application of zinc oxide ointment. This treatment is less annoying than the cutaneous hydrargyrism so often caused by the traditional gray ointment.

Another method of cure is to shave all the hair and burn it, then apply to the skin a 10 per cent calomel ointment, sulphur ointment, or zinc ointment containing grs. x of beta-naphthol in the ounce. Schamberg remarks that lotions being more cleanly than ointments, are to

be preferred, and recommends tincture of cocculus indicus, the fluid-extract of staphisagria, and especially petroleum-olive-oil-balsam-of Peru lotion.

Prurigo. Prurigo is an affection most common in the very poor and undernourished, and when it affects the scrotum the lesions will be found on the perineal surface, upon and around the raphé. The etiology of this skin affection is obscure. It ordinarily begins early in life with urticarial lesions, and often persists for years, or a whole lifetime, treatments having no effect. As the condition progresses the lesions take the form of pruriginous papules. On the scrotum a lichenoid state is eventually formed with a gray pigmented plaque of indurated skin which resembles morocco leather. Galvanism and radiotherapy have both proved useful in controlling this cutaneous affection.

Lupus, lichen of various types, psoriasis and other skin diseases may affect the scrotum, and it is a very common site also for such syphilitic lesions as condylomata, and soft papules and recurrent syphilides. Eczema in its different manifestations is a not infrequent occurrence in this region, treatment in all cases being the same as for the particular cutaneous lesion elsewhere on the body. As the secondary manifestations of syphilis often produce an abundant papular eruption upon the scrotum, the situation of the affected parts may lead to the papules becoming ulcerative, exudative or even somewhat pruriginous. Such lesions should be carefully cleansed twice a day and receive applications of equal parts oxide of zinc, vaseline and lanoline; also a powder of equal parts talc and zinc oxide. The scrotum may be separated from the thighs by a sheet of dry wool dusted lightly with the powder, and a suspensory worn to prevent chafing and irritation.

Epithelioma.—Clinically, three forms of epithelioma are found in the scrotum, the warty outgrowth, the epitheliomatous ulcer, and the epitheliomatous fissure. The first of these, which is often known as tar-workers' eczema, may for a long time persist as an apparently harmless soft warty outgrowth, eventually coming to a head which when removed, leaves a pigmented eczematous patch which later extends and assumes the well-recognized appearance of a carcinomatous ulcer. In this second form the inguinal glands are enlarged, but aside from this, the process may be limited and the condition progress very slowly, such patients often surviving for many years without any treatment, or attempts at extirpation. When the lesion assumes the third form, that of the epitheliomatous fissure, extension takes place more quickly, as the growth eats its way downward invading the underlying tissues, and the extension to the glands will be wider and more rapid. This is the "chimney-sweep's cancer" so frequently mentioned in English urological works, but not often encountered in our own country.

Etiology.—The peculiar liability of chimney-sweeps to epithelioma of the scrotum has long been an observed fact in England, and was attributed to the irritant action of the soot upon this particular cutaneous area. But as England is by no means the only country where "sweeps" are employed in considerable numbers, the high incidence among English sweeps alone, has always lacked an adequate explanation.[4] More recently it has been established, both here and in the Eastern Hemisphere, that prolonged exposure to tar and its products tends to produce ulceration of the skin, particularly of the scrotum. Two years ago an extensive investigation of the etiology of this particular form of epithelioma was undertaken at the Manchester (England) Royal Infirmary, where it was found that in the previous twenty years, 141 cases of scrotal cancer had been treated at that hospital, *only 1 of which occurred in a chimney-sweep.* Most of the patients were "mule-spinners" in the Lancashire cotton mills, and investigation showed that men thus occupied, from their position while at work, were constantly exposed to the irritant effect of lubricating oil and slight but continued trauma upon the left anterior aspect of the scrotum, as that part of the body came in contact with the moving carriage of the machine. Thus, in the mule-spinner at least, the etiology of epithelioma of the scrotum would seem to depend on chronic irritation, the result of friction and contact with oil. These conditions are by no means confined to English workmen, and similar investigations might be of interest in this country. All workers in tar or paraffin, or those exposed to contact with oil upon those cutaneous areas, such as the scrotum, particularly subject to irritation, should be enjoined to exercise especial prophylaxis of those parts.[32]

Treatment.—Radical removal offers the best hope of cure. Metastasis to the glands is prone to take place early, which makes it of very great importance that all possible areas of infection should be dissected out, and the inguinal region cleared of all foci of recurrence. The growth in the scrotum should be excised with a wide surrounding margin of healthy tissue, the whole thickness of skin and dartos being cut out and the glands and adjacent fat in both groins fully removed. Anastomosis between the superficial lymphatics on both sides is very free, and if the growth has reached the median raphé, early metastasis to either groin is likely to take place. The scrotal growth and the tissues of the groin should be removed through separate incisions, much as one proceeds in cases of lingual cancer, the best incision for removing the glands being one parallel to and below Poupart's ligament, extending from the anterior spine to the spine of the pubis; from the center of this a vertical incision is carried a short distance down the thigh. This incision allows good exposure of the infected tissues and their easy removal.

Radiotherapy.—The authors have had no experience in the application of radium or roentgen-ray to this form of epithelioma, and have been unable to find any recorded in literature. It is probable that the

scrotum, as in the case of the penis, offers so good a field for complete excision, that all cases coming under observation early enough to give hope of cure, are perfectly amenable to surgery. However, the measures which have proved so effective in the treatment of epithelioma elsewhere in the body, should be equally useful upon the scrotum, and especially, in the postoperative treatment of the inguinal area.

The successful use of radium in the treatment of lymphosarcoma of the scrotum, a very rare condition, was recently reported from France.[26] The patient was aged twenty-four years, and after excision of what was supposed to be a hydrocele, rapid recurrence demonstrated that malignancy was present. Four radium applications were made and three months later the growth had disappeared and the scrotum become normally supple.

Lues of the Scrotum.—Practically all the cutaneous manifestations of syphilis may appear upon the scrotum. Beside the chancre, the various types of eruption—macular, papular, nodular and pustular—are frequently seen, and gummatous lesions are not at all uncommon.

Chancre.—Compared to its appearance upon other parts of the genitals, however, chancre of the scrotum is relatively rare. Of 121 genital chancres seen by Thompson, in private, clinic and army practice, only 2 were upon the scrotum, and the authors' experience corresponds in general to this observation.

When beginning upon the scrotum the chancre's first appearance is usually as a round red spot, small at first, but rapidly growing larger. The initial manifestation is quickly followed by desquamation of the superficial epithelium, and in the denuded area small cracks soon radiate so as to form an ulcer of generally roundish form, which is not very deep and has an indurated edge.

Other Luetic Lesions.—One does not often see macular lesions of the scrotal skin, and papular eruptions of similar type are not very common. The lenticular type of papular lesion is, however, fairly frequent in occurrence, both in the moist and dry form, the moist being perhaps the more common of the two. Occasionally an almost cauliflower appearance will be assumed by a moist papular eruption on the skin of the scrotum, even offering some difficulty in the differential diagnosis of malignancy. Still another form of luetic infection which is occasionally manifested in this region is gumma, although in the great majority of instances it is not primary but an extension of a process having its origin in the testicle.

Elephantiasis of the Scrotum.—This lesion to which most textbooks on urology give a considerable amount of space is not endemic in the United States, those few cases which have been observed here being importations. It does occur, however, in our tropical possessions, and is of interest to naval surgeons, and those whose professional activities take them into tropical regions. Out of 222 operations performed at the United States Naval Station at Tutuila, Samoa, during the year 1906, no less than 77 were for the removal of these elephantoid

tumors, varying in size and weight all the way from 5 to 60 pounds.[15] The condition is caused usually by the ova of *Filaria sanguinis hominis*, which block the lymph channels through which the lymph circulation returns to the scrotum. Chronic inflammation may have the same effect, which gives us what is usually termed *pseudo-elephantiasis* or *esthiomene*. This is most commonly a syphilitic hyperplasia, and is not infrequently seen in negroes native to this country. Operation is the only remedy and recurrence though possible, rarely takes place.[1]

Granuloma Inguinale.—Granuloma inguinale which was discussed in the chapter on the penis (see p. 149) must also be considered under diseases of the scrotum. The lesion begins as a relatively insensitive papule which later breaks down and, resisting all attempts at healing, spreads rapidly over the surrounding tissues. Its course in the scrotal area is the same as that described for the penis. The diagnosis is readily made by the characteristic appearance and the detection of the Donovan organism, and treatment by intravenous injection of tartar emetic has proved effectual.

Ducrey's Bacillus.—Chancroid upon the scrotum does not differ from that upon the penis. Here, as there, it is a specific, local, contagious auto-infectious venereal ulcer which flourishes only where soap and water are not esteemed.[17] Although beginning as a single ulcer, auto-infection is so constant that by the time the lesion comes under observation it is a common occurrence to find several ulcers in close relation, which if untreated may spread to any part of the external genitalia. Sometimes chancroid of the scrotum may be mistaken for an acne pustule, or an insignificant boil, when it takes the follicular form, having its starting point in the mouth of a sebaceous gland.

Gangrene of the Scrotum.—The average text-book contains little or no reference to scrotal gangrene. Yet gangrene of the scrotum is by no means as unusual as this literary silence would lead one to suppose. Within the past four years a number of authoritative articles have appeared reporting extensive series of cases, notably at Bellevue Hospital, New York, and the Philadelphia General Hospital, showing that in large centers of population at least the condition is not unlikely to be encountered. The first author who gave particular attention to this disease entity appears to have been Whiting[37] who divided the cases into five groups:

(1) Grangrene due to the action of bacteria either through the specific chemical substance which they liberate or as the result of vesicular obstruction due to the inflammatory process to which they give rise. (2) That due to interference with the nutrition of the part by obstruction of the circulation, the causes being other than micro-organismal. (3) That due to direct mechanical or chemical action. (4) That due to thermal agents. (5) In which the gangrene is caused by injury of the so-called trophic nerves.

Dealing with the subject as a definite disease of the scrotum, we shall therefore, consider only those cases falling under the first classi-

fication; the remainder being considered under wounds or other trauma or disease of the parts involved.

Acute fulminating gangrene of the scrotum and penis is, according to Campbell[5] a disease characterized by an abrupt spontaneous onset, a rapidly ensuing inflammation with marked edema, and subsequent necrosis of the superficial tissues of the genitals. The condition is usually accompanied by generalized sepsis and prostration. In private

FIG. 44.—Gangrene of the scrotum showing a great degree of swelling with the formation of blebs under the skin at several points. The penis has been surrounded by the excessive edema to such a degree that it can hardly be seen.

practice it is seldom encountered; indeed, it is practically always in large hospitals that one must look for it, for smaller institutions are wont to refuse such cases, and moreover its incidence seems to be directly related to physical debility associated with more or less bodily filth, circumstances more often to be found in the patients of large institutions than elsewhere in medical practice. Sudden gangrene of the scrotum has been recently suggested as a suitable designation for the particular type to which we have reference,[20] while Randall has

described an extensive series of cases under the name of idiopathic gangrene.[27]

Etiology.—Whiting considered the most probable disposing factors of scrotal gangrene as: (1) The laxity of the cellular tissue which permits marked infiltration; and (2) the looseness of the skin which diminishes resistance to infection. Age apparently is no factor, Marcy recording a case in a child aged two years, while Campbell had a patient aged seventy-one years. Analysis of reported cases does not point to trauma as of any great etiological importance, but it is possible that concomitant lesions as urethritis, bubo, phimosis, etc., may afford a portal of entry.

FIG. 45.—Gangrene of the penis and scrotum following periurethritis.

Bacteriology.—Many observers believe the condition to be identical with erysipelas, as clinically and pathologically it appears as a cellulitis, the onset, manner of extension, the red, hot, painful and edematous nature of the lesion being characteristic of such a type of infection. The fact that a number of different organisms have variously been accused as causative agents indicates a very general inclination to believe that it is due to specific infection, as well as the prevailing uncertainty in regard to it. In all the cases studied by Campbell "a long chain variety of streptococcus" was demonstrated, which led to the belief that we may be dealing with "a cellulitis of the superficial tissues not unlike erysipelas. . . . It seems reasonable, therefore, to consider these cases as intimately allied to erysipelas,

if not typically the condition itself, the presence of the hemolytic streptococcus of the *streptococcus longue* type being corroborative."

Symptoms and Cause.—The most marked phenomenon in this type of infection is the sudden explosion when the victim is apparently in his normal state of health. The sudden onset is only equaled by the rapidity of the ensuing symptomatology; chill, fever, prostration, pallor, rapid pulse, even nausea, vomiting and delirium, precede and accompany the development of the scrotal swelling. The affected parts soon assume enormous proportions sometimes swelling four or five times their normal size. The tissues are hot and exquisitely painful, with skin tense and shining and very sensitive to the slightest pressure. The reddened area may even spread as high as the abdominal wall. Within two or three days edema is marked, the shining redness becomes dull, exudation commences, especially in the dependent portions, and the greenish hue of gangrene, together with its disgusting characteristic odor, will be perceptible. Soon a line of demarcation is established and the gangrenous areas, if multiple, coalesce to form one gangrenous mass. Involvement of the penis does not extend beneath the shaft of the corpora cavernosa, and that of the cord and testicles is limited by the sheath and tunica vaginalis. Sloughing of the testicles does not occur, and the skin of the thigh is singularly free from involvement. In neglected cases, the sloughing gangrenous mass having become definitely demarcated, separates, and removal of the scrotal tissues either by necrosis or the knife, leaves the testicles dangling unprotected between the thighs.[5] Masses of necrotic tissue may come away at each dressing of the wound, but the greatest care must be exercised to avoid sharp secondary hemorrhage, which is likely to take place at this stage. In order to relieve the tension upon the cords and prevent injury to the bloodvessels, it is necessary to support the testicles by bringing them up close to the body.

The mortality is high, but if recovery does take place, regeneration is rapid and complete. The first healing is a granulation between the two testicular coverings, which rapidly adhere the one to the other, and soon form a single pear-shaped mass. With each dressing the skin seems to creep down over the gauze under-packing, pushing it ahead of it as it granulates to the testicular surfaces. In most cases there appears to be less of an actual proliferation of the scrotum than an apparent voluntary stretching of the remnant tissue, and if properly dressed, in due time a new scrotum forms, having the normal elasticity, and being freely movable on the underlying and encasing tissues of the testicle.[5]

Treatment.—Free and early incision gives the best results. The incision must be long and deep, and gauze drainage constantly maintained by frequent renewal of the dressings. Irrigations with hot potassium permanganate, 1 to 500, should be frequently administered, and the testicles kept constantly protected and supported by bandaging in such a way as to keep them pressed closely up against the perineum.

Hydrocele.—Hydrocele is an accumulation of fluid within a serous sac, but the term is more often specifically applied to a collection of clear fluid within the tunica vaginalis of the scrotum, sometimes termed *vaginal hydrocele*. All fluid accumulations of this character may be either acute or chronic.

FIG. 46.—Bilateral hydrocele which has distorted the scrotum so much that the penis has disappeared. Both sides of this enlarged scrotum transmit light when an electric torch is held behind them.

Acute Hydrocele.—This form is always due to inflammation and infection of the testicle or epididymis, or may follow the receipt of an injury. Symptomatic hydrocele is very often a sequel to gonorrhea or tuberculosis of the epididymis, gonorrhea producing the acute type. Hydrocele in its acute form may also be due to infections with such

organisms as the colon bacillus or pneumococcus, the presence of new growths, or may occur in the course of such diseases as typhoid fever or lues. In fevers, the formation of hydrocele resembles the effusion into the joints or the pleura; it is the result of a blood infection or perhaps follows chemical irritation.[8] If hydrocele forms in the course of a general disease, it is wisest to tap it at once and make a microscopical search for the specific organism which has caused it. But as an acute hydrocele is practically always the indication of the existence of an epididymo-orchitis, treatment must be directed toward the lesion in the testicle. When the primary affection has been done away with, the hydrocele will usually subside without further attention. Rarely, it may become tense and have to be tapped. Occasionally it may go on to suppuration, in which event it is termed a *pyocele.*

Etiology.—Hydrocele is usually found in men who have attained or passed the age of forty-five years. This fact has led many observers to believe that it is etiologically dependent upon the changes in the cord induced by the vascular conditions which are attendant upon the decline of virility due to advancing age. At any operation upon hydrocele it will be evident that changes have taken place in the tunica vaginalis, the membrane being thicker and less translucent than under other conditions, as for example, when operating for hernia in that region. Though this inflammatory condition may be either primary or secondary to the appearance of the hydrocele, it is more likely to be a secondary change, and this observation would rule out the possibility of the condition found in the tunica vaginalis being the cause of the hydrocele. Corner found that the walls of the spermatic artery were thickened and atheromatous, thus diminishing its caliber, and lessening the amount of blood able to reach the testicles. From this he argued that a decline in the activity of the testicle would inevitably follow, and that the gland might even undergo fatty changes such as are observed after ligation of the spermatic artery. In the height of its activity, the rich arterial blood supply of the testicle demanded many veins for the depletion of the gland. Hence, the appearance of those veins, and perhaps of varicocele, at puberty. In later years the spermatic artery becomes narrowed, as do the hypogastric arteries when the placenta has ceased to exist, and no similar changes occurred in the corresponding veins; the blood stream in them becoming more and more sluggish, and the testicle and its membranes becoming passively congested. Passive congestion leads ultimately to chronic inflammation which, in the case of the tunica vaginalis, will cause its thickening and perhaps formation of a hydrocele.[8]

Other investigators have suggested that in certain cases hydrocele may be due to the bursting of an epididymal cyst into the tunica vaginalis, but actually we have no adequate explanation of its cause.

Congenital Hydrocele.—In infants hydrocele will sometimes occur before closure of the funicular process, making a communication between the interior of the sac and the peritoneal cavity, though the

opening is usually so minute that no hernia can take place, and the fluid is retained in the sac instead of spontaneously flowing out into the abdomen. Hydrocele may also occur when the funicular process is closed at its superior outlet, the fluid thus distending both the tunica vaginalis and the funicular process. This is termed *infantile hydrocele.*

Contents of the Sac.—The fluid content of a hydrocele closely resembles ordinary blood serum, it is viscid and without odor, usually of pale yellowish color, though the occasional presence of cholesterin crystals may give it a glistening appearance so that it looks almost opalescent. Its specific gravity runs from 1.020 to 1.025. Fibrinogen is its chief organic constituent, about 6 per cent, but marked and relatively high amounts of alkaline carbonates and sodium chloride show that the tunica vaginalis exercises a selective action, and demonstrate that the fluid is something more than a mere physical effusion into that membrane.

Sometimes on opening a hydrocele so-called fibrous bodies will be encountered. These are concretions of carbonates or phosphates which have become encrusted with fibrinous material. Histologically they are found to consist of parallel or concentric layers of tissue, very dense and fibrous, a few widely scattered cells of connective tissue being made out between them.

Location.—If the hydrocele occupies but one side, the swelling in the scrotum will assume a pear-shape, with the larger end below. Above the smooth elastic tumor it is possible to palpate the spermatic cord so as to define the margin of the external inguinal ring, a procedure which demonstrates that the swelling is not of abdominal origin. Dull on percussion, and at times imparting a slight thrill, a slight impulse will usually be felt when the patient is directed to cough, though some authorities aver that this will not occur unless the hydrocele extends into the inguinal canal or is complicated by hernia.

When the tumor is bilateral it will be oblong or rounded instead of pyriform, and will usually be so large and heavy as to stretch the scrotal skin, making it tense and shining, and descending so far as to completely conceal the penis. This is likely to produce inflammation of the skin from dribbling of urine over the parts, when the stream cannot be projected in the normal manner, giving the patient added discomfort.

Diagnosis.—While it is ordinarily easy to recognize the condition, complications are so likely to be present that it is necessary to exclude them, or to gain full information concerning them, before any treatment can safely be undertaken. Three methods of diagnosis are available, which may be used singly or in conjunction, as occasion requires. These are the test for translucency, the ability to isolate the tumor, and puncture. In true uncomplicated hydrocele transillumination will cause the whole tumor to glow with a pinkish light, but the translucency will vary in individual cases, due to the different

thickness of the skin and the constitution of the contained fluid. Usually the testicle will cast a shadow so that its location can readily be ascertained. Corner advises that in demonstrating the presence of a small hydrocele by means of transillumination the hand which is used to render the hydrocele and skin tense must prevent the fluid from collecting at the bottom or back of the scrotum by squeezing it up above the testicle where the translucency can be demonstrated.

Hernia can be excluded if the examining fingers can approximate above the mass and feel beneath them only the normal spermatic cord and the unobscured margins of the external ring. Sometimes in very young children a hernia will appear translucent, but it can

FIG. 47.—Encysted hydrocele simulating supernumerary testis.

usually be detected by its reducibility, as it is impossible to reduce hydrocele. The probability of hernia is slight when it can be established that the mass runs into the inguinal canal and there is no impulse on coughing.

Hydrocele in a hernial sac is occasionally met when we have an effusion of fluid into the sac of a hernia, the orifice of which has in some way become blocked, as by adhesions, or an omental plug. As there will usually be a previous history of hernia, differential diagnosis should not be difficult. Its proved connection with the abdomen when the tumor can be palpated beyond the external ring, will offset the translucency usually demonstrable. *Hematocele* may complicate the course of a hydrocele, and is very difficult to differentiate. It usually

PLATE IV

Multilocular Cyst of the Scrotum Arising from the Epididymis.

results from trauma of some sort, and this will be in evidence by bruising of the skin. It is less elastic than hydrocele and is also impervious to light. The signs of *pyocele* are very similar to those of hydrocele, except that the scrotal skin will show inflammation, tenderness and edema, while the general systemic effects—fever and rapid pulse—will serve as additional evidence as to the nature of the mass. *Cysts of the epididymis* occasionally complicate the diagnosis of hydrocele, but can usually be identified by the possibility of distinguishing and separating the testicle from the swelling.

Age.—The hydrocele of infancy almost always bears some relation to gastro-intestinal fermentation; in children and adolescents some abnormal condition of the cord or testicle is usually a causative factor; in the middle-aged and elderly, the vascular changes which accompany the decline of virility probably have much to do with its incidence. In infants and youths a hydrocele should not be left untreated, for as it increases in size the vasa efferentia, as well as the nerves and blood-vessels will be stretched and damaged by the forcing apart of the testis and epididymis. Because of this there will be a gradual interference with the proper external secretion of the gland, and later internal secretion will also be hindered. Therefore, it will readily be appreciated that the importance of these considerations decreases as the age of the subject increases.

Tapping.—A hydrocele from which hernia has been positively excluded may be tapped, although in adults this can merely be regarded as a palliative measure, applicable where operation is refused, or for some reason is contraindicated. In children, on the other hand, this procedure often effects a cure, and repeated tappings at greater and greater intervals in an old man may carry him along until the causes which originally produced the hydrocele have ceased to be operative. But in younger adults, tapping alone should never be looked upon as a means of cure.

Varicocele.—In the condition termed varicocele, the veins of the pampiniform plexus are dilated, elongated and tortuous. The vein most commonly affected is the spermatic, though not infrequently, the deferential or cremasteric veins will be likewise involved in the pathological process.

Veins of the Pampiniform Plexus.—The veins begin in the blood spaces beneath the tunica albuginea of the testis, unite with those from the epididymis, then anastomose with the radicles from the dorsal vein of the penis and also with those from the external and internal pudic veins. On their arrival at the inguinal canal they unite into several trunks, and these trunks in turn later unite into a single vein. On the right side the vein so made enters the inferior vena cava; on the left it makes a right-angled junction with one of the renal veins. These veins are surrounded only by a loose envelopment of fascia and are dependent and practically unsupported, conditions which readily lend themselves to pathological accident.

About 95 per cent of all varicoceles seen are located on the left side. The reason for this is not clear, and many theories have been advanced to account for it. It is, moreover, a condition peculiar to adolescence and early manhood, and would therefore, seem to have some definite relation to the period of greatest activity of the sex glands. Many writers believe that it is due to the right-angled junction of the vein with the left renal vein.

Pathologically, we may see veins in any degree of tortuosity and dilatation up to the stage of complete breakdown of the valves, with the vessel walls atrophic and greatly thickened. Phleboliths are sometimes found in the veins. Diagnosis is usually easy, as the feel of the enlarged veins is so characteristic as to be almost certain of recognition. The testicle, except in the remote possibility of a right-sided case, hangs lower on the left side, often so low as to make a constriction in the scrotum above the testicle. The scrotum itself is very pendulous, relaxed and smooth in appearance, the varicocele frequently being visible either as a tumor in the upper part of the scrotum, or as a well-defined mass surrounding the testicle, the greater part of the tumefaction being below the gland. If the scrotum be lifted up, as the patient lies prone, the varicocele will immediately empty itself, but as soon as he is directed to stand erect, it will refill, and this may be hastened by the examiner placing his finger lightly upon the external inguinal ring.

Treatment.—The operative treatment of varicocele will be considered a little further on. But in most cases surgical intervention is not only unnecessary but unwise. The case against operation was very well stated by one of our leading surgeons on the occasion of the entrance of the United States into the World War.[2] The majority of men suffering with this lesion show, after long observation, that the condition, as a rule, spontaneously disappears. Varicocele is observed most frequently after puberty and before the age of twenty-one, and, as a rule, it disappears at about the age of twenty-five and with few exceptions, before thirty. Those individuals who have varicocele and are neurasthenics in addition, as frequently happens, are rarely relieved of their neurasthenic symptoms by the operation for varicocele, and in the excision and ligation of the thin-walled dilated veins there is always the danger of hemorrhage even when the greatest care is taken, which may have as sequels thrombosis, hematoma or epididymitis, or in rare instances, atrophy of the testicle. And even in those cases where the operation is properly carried out with little or no swelling of the testicle or thrombosis of the lower vein stumps, it is possible for a hydrocele to develop within a comparatively short time, which will make the patient's condition infinitely worse than when he had the original varicocele.

If hernia exists in conjunction with varicocele, the danger of epididymitis, testicular atrophy and secondary hydrocele are greatly increased by excision of the varicosed veins during the radical removal

of the hernia. Therefore, except in cases where the veins are of huge size, it is better to follow the advice of another eminent surgeon,[17] who recommends that the patient should be advised as to his sexual hygiene, perhaps instructed to wear a suspensory bandage and treated for neuralgia of the testicle, if this is a feature of his condition.

Hematocele.—An effusion of blood into the tissue of the scrotum or testicle is termed a *hematoma*. A hematocele is properly a hemorrhage into a cavity which already exists, as, for example, the tunica vaginalis, while a hematoma is a hemorrhage which forms its own cavity. A hematocele is practically always a sequel to trauma. Hematoma of the scrotum without rupture of the skin is a not uncommon occurrence, especially in boys and athletic young men, and the only treatment usually necessary is cold applications combined with rest and elevation of the parts. Hematocele, on the other hand, is a serious lesion often requiring operation, and the differentiation between the two conditions therefore assumes considerable importance. It is possible to have both hematoma and hematocele, as hemorrhage into the sac of a hydrocele will frequently be attended by infiltration of the scrotum or testicle with blood.

Etiology.—Hematocele is due either to a lesion of some subcutaneous scrotal vein as sometimes occurs in tapping a hydrocele, or more commonly to trauma as occurs after the receipt of a severe crushing injury. Vaginal hematocele is sometimes spontaneous, but that occurring in the scrotum or testicle is always of traumatic origin. A vaginal hematocele may leak through the incision made in tapping a hydrocele and thus reach the subcutaneous tissues of the scrotum, but usually the effused blood lies between the dartos and the tunica vaginalis, under the testicle, in such a way as to raise the gland perceptibly. No hydrocele has ever been reported as appearing in this area, so that will serve as a valuable point in differential diagnosis.

Pathology.—When the effusion of blood into the sac is a slow process the blood will coagulate, and the walls of the tunica vaginalis be gradually overlaid with fibrin which adheres to the surrounding connective tissue, while the wall gradually thickens and becomes rough and uneven, so that it ceases to suggest the appearance of a serous surface. As the clot is absorbed and organized into connective tissue the walls become still thicker. When a hematocele has been in existence for a long time the surrounding sac-wall will be found to have become calcareous or even in rare instances, cartilaginous.

Symptoms.—There is a wide difference in the rapidity with which a hematocele will form. When there has been violent trauma its formation will be extremely rapid and attended by pain; but in spontaneous cases there will be practically no pain, the swelling gradually augmenting in size, likewise, if hydrocele is already present, decreasing in translucency as the hemorrhage continues. In either case the process of coagulation and organization is very slow, and it is possible to observe upon the scrotal skin an increased warmth and irregularity of surface

due to the presence of underlying clots. When these clots remain after the plasma is absorbed they can be palpated as masses in the scrotum and the dark coloration of the effused blood is visible through the skin.

Diagnosis. Diagnosis is always very difficult, and in the majority of cases can hardly be positively established without an exploratory incision. The differentiation from hydrocele or hernia is not a hard matter, but tumors of the testicle present many points of resemblance, and it is a sad and significant fact that most of the museum specimens of hematocele have been removed under the mistaken impression that malignancy of the testicle was being extirpated, thus quite unnecessarily subjecting the unfortunate patient to partial or complete sterilization. A surgeon would therefore, be quite justified in tapping a non-translucent swelling in the scrotum, when other means have failed to establish a diagnosis. When hematocele is tapped, a quantity of dark-colored blood will usually flow out, although the existence of clots may at times prevent this. If the tumor mass is due to gumma, little or no blood will be in evidence, while from malignant disease there will be a slow but continuous outpouring of bright red blood. It seems unnecessary to emphasize the need for the utmost care in surgical asepsis, and where there is any question of malignancy, preparation for immediate subsequent operation should be made in advance.

Spermatocele.—Spermatocele has been recently defined as a retention cyst of the scrotum which is, or has been, in communication with the semen-carrying system.[9] In size it may vary all the way from that of a small pea to that of a baby's head, but the majority are relatively small and contain but a few ounces of fluid. The frequently encountered small cyst hardly bigger than a grain of millet is usually a simple retention cyst and contains no spermatozoa.

Contents.—The fluid contained in a spermatocele is usually of a milky appearance somewhat resembling barley water, and in many cases is opalescent. On standing it gradually separates into two layers, relatively clear above but in the lower layer showing very white, and under the microscope displaying great numbers of spermatozoa with a few lymphocytes and epithelial cells. The spermatozoa retain their motility for several hours after the fluid has been withdrawn from the sac, but sometimes they are quite without motility and in cysts arising from a senile testicle spermatozoa may be wholly absent. The specific gravity of the fluid ranges from 1.002 to 1.006, and its reaction is slightly alkaline. The albumin content is usually about 0.3, or even as high as 0.5 per cent.

The fluid from a chylocele is likewise milky, but its color is yellowish-white and much more dense and opalescent. When allowed to stand this fluid also separates into two layers but both to the naked eye and under the microscope has an appearance similar to milk, the denser layer being above with many fat globules in a state of fine emulsion.[38]

Structure.—The walls of the cysts are made up of interwoven strands of connective tissue, among which can be found bundles of smooth muscle fibers. These bundles arise from the smooth muscle of the vasa efferentia and the canalis epididymis, and when found, it is claimed point strongly to the existence of spermatocele. The cysts are lined with ciliated or cylindrical epithelium when of recent origin; in the older ones the lining is of pavement epithelium.[9]

Symptoms.—A truly pathognomonic group of subjective symptoms is seldom observed; that is, severe pain in the testicle and swelling under conditions productive of sexual excitement. Usually however, there is little or no pain, only a feeling of distress. A swelling or tumor following trauma and slowly progressive, should arouse a suspicion of spermatocele. The only objective finding will be the tumor, if extra-vaginal, appearing as a globular mass above the testicle, but if intra-vaginal displacing the testicle downward and forward. In the intra-vaginal type a hydrocele may be coexistent, so that the nature of the tumor will not be in evidence.[39]

Diagnosis.—If the patient gives a history of trauma followed by a slowly progressive tumor in the scrotum, and examination shows a pyriform mass which displaces the testicle downward and forward, or a globe-shaped mass on top of the testicle, we probably have to deal with a spermatocele either extra- or intra-vaginal, as will be indicated by the location of the tumor. The finding of spermatozoa in the withdrawn fluid cannot be regarded as positive proof needing no further corroboration, as hydrocele sometimes contains a few spermatozoa.

Age of the patient will not assist much in making the diagnosis for it has been stated that these cysts occur at any time of life after the testicle begins to function. In 90 cases tabulated by Whitney[38] it was found that there were

Under 20 years	1 case
Between 20 and 30 years	11 cases
Between 30 and 40 years	11 cases
Between 40 and 50 years	17 cases
Between 50 and 60 years	25 cases
Between 60 and 70 years	16 cases.
Between 70 and 80 years	8 cases
Over 80 years	1 case

In any event, diagnosis before tapping is a rather difficult matter. Small cysts must be differentiated from the minute indurations of gonorrheal or syphilitic origin, although here a carefully elicited history will be of service. In a few cases the tension within the sac may be so great as to produce simulation of a solid tumor—carcinoma or sarcoma—but in large-sized swellings the chief difficulty in differentiation is from hydrocele, hematocele and chylocele. An important diagnostic point is the presence of the testis below and in front of the swelling, a point which should always be kept in mind when tapping. When hydrocele and spermatocele exist together on the same side the testis is between the two swellings.

Treatment. Treatment is generally operation, dissection of the sac. Aspiration, incision and the injection of irritants, iodine or phenol,

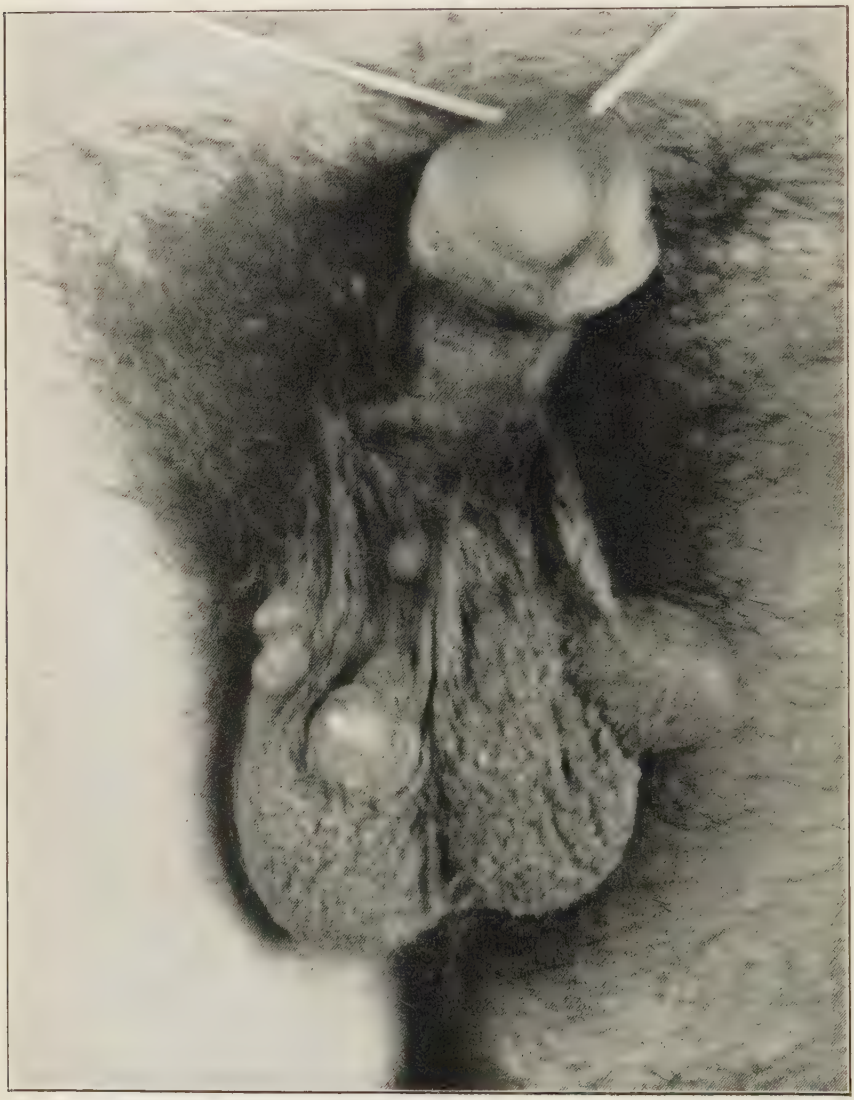

FIG. 48.—The sebaceous cysts of the scrotum here shown varied in size from that of a grape to that of a pullet's egg. They were all dissected out under procaine anesthesia with complete relief.

formerly regarded as proper measures, have now been practically abandoned.

Other Cystic Conditions. –Multiple sebaceous cysts of the scrotum are sometimes observed. In a recruit examined for the Marine Corps during the World War, an interesting case was reported.[15] The subject was aged twenty-five years and had first noticed the appearance of a cyst upon his scrotum when he was about fifteen. The lesion started as a small yellowish-red swelling near the top of the scrotum which slowly increased in size. Before the first cyst had attained much size others developed, and at the end of the first year after the condition was initiated there were 7 tumors on the right side of the scrotum and 8 on the left. Since that time other growths have made their appearance in no definite sequence, until at the present writing 114 cysts are noted, varying in size from that of a marble to that of a small bird shot. Most of the growths gave no symptoms of any kind, but a few of them broke down with a typical discharge. The subject's health was not affected and the condition was not regarded as a disqualification for service in the United States Marine Corps. At different times during the preceding ten years this man had had identical lesions upon his face and left elbow, which had been removed as they appeared. We have since seen a similar case which is shown in Fig. 48.

Calculi and Concretions.—Occasional reports of scrotal calculi have from time to time appeared in the literature. Oertel[25] has described a case where 8 calculi were removed from the scrotum of a man aged thirty-eight years, who came under treatment for 2 urinary fistulæ situated on the penis, accompanied by much swelling and exudation of pus. More recently, a similar case was reported from India,[14] in which one fistula was in the penile urethra and the other in the scrotum. In this case there was a history of a small stone impacted in the urethra seven years before, unsuccessful attempts to remove which had been followed by suppuration. This easily explained the origin of the stone now lodged in the scrotum, which had doubtless migrated there through suppuration of the urethral wall.

A concretion in the scrotum may be a calcified hematoma. One such mass on sectioning was found to present a calcareous shell enclosing cholesterin crystals and red and white blood corpuscles.[13]

OPERATIONS UPON THE SCROTUM.

Anesthesia.—In doing operations upon the scrotum or its contents there are several important drawbacks to the use of local anesthesia. Sacral anesthesia serves only to block the nerves of the skin, whereas to produce a proper degree of insensibility to pain, it is imperative also to block the nerves of the cord at the point where it passes through the external inguinal ring. In the combinations of solutions adrenalin should never be used, because it is not only toxic but in this particular area greatly increases the operative hazard, for though it temporarily stops bleeding, later hemorrhage is almost certain to occur and result

in hematoma formation. All wounds of the scrotum, whether surgical or accidental, should be drained very thoroughly, in order to prevent infiltration of the areolar tissues by blood.

Procaine Infiltration. The method employed at the Mayo Clinic is as follows:[24] The anesthetic drug employed is procaine, which replaces with perfect satisfaction the German novocaine; 0.5 per cent strength in 0.45 per cent salt solution, and 10 drops of 1 to 1000 epinephrine solution is added to each 100 cc. of procaine solution immediately before use. Twenty to 25 drops of epinephrine is the maximum used in any one case. The cutaneous surfaces are prepared as for laparotomy, and with the smallest hypodermic needle, an intradermal wheal is raised about 1 inch internally and below the anterior-superior iliac spine. A larger needle, 8 to 10 cm. long, is then introduced through this wheal, and fan-wise injections in the same plane are made below the abdominal wall. As soon as the second needle is passed through the dermal wheal it enters subcutaneous tissue offering but little resistance. Resistance increases on passing through the fascia, but lessens as the needle pierces the muscle tissue of the external oblique, increasing once more when the fascial plane between the internal and external oblique muscles is encountered. In creating a wall of anesthesia it is important to inject continuously, both during the advancement and withdrawal of the needle. The injections extend from the ilium to the rectus abdominalis muscle, the last medial deep injection being made into the sheath of the muscle. Subcutaneous injections are then made into the same plane as the deep injections. Usually 40 to 50 cc. of solution are sufficient for these injections.

The pubic spine is next palpated and an intradermal wheal raised just medial to the cord. The cord structure is then grasped between the thumb and forefinger of the operator's left hand close to the external inguinal ring. Injections are made entirely around these structures and then directly into the coverings of the cord, after which the cord is well massaged. When the injections are made as the needle advances the veins of the cord are rarely punctured, and there is no danger of wounding the vas, as it is readily pushed away by the outflow of solution. About 15 to 25 cc. of solution is necessary here.

Injection is next made through the pubic wheal along the margin of the pubis above the base of the penis as far as the opposite pubic spine. The overlying subcutaneous tissues are then infiltrated by fan-wise injections to the skin. The entire base of the scrotum is infiltrated at the abdomino-scrotal juncture. Injections may be made downward from the pubic wheal, the left hand holding the scrotum aside and palpating the tissues and the end of the needle while the injection is being made. The solutions should be carried well into the sulcus between the horizontal ramus of the pubis and the base of the penis. A lateral scrotal wheal is next raised and injection made transversely across the posterior aspect of the scrotum according to Braun's technic. About 50 cc. of solution is used in the circumferential injections, and

the base of the scrotum is well massaged, in order to facilitate complete diffusion of the fluid.

An entire circumferential field block of the base of the scrotum is made, whether the operation is on one or both sides. If bilateral procedures are employed, para-iliac field block and injection of the cord structures are carried out on the opposite side in the manner described. A total of 125 to 150 cc. of solution is needed for unilateral operations, and from 200 to 250 cc. for bilateral operations. Twenty drops of epinephrine is generally used when operation is upon both sides.

Operative Treatment of Hydrocele. The necessity for assurance that a hydrocele is not complicated by hernia or otherwise, has already been emphasized. There are several procedures for the cure of hydrocele and good judgment is sometimes required in order to select that one best suited to the requirements of the individual case.

Tapping or Closed Operation.—Evacuation of the fluid content and injection of the sac with phenol was a common method of dealing with uncomplicated hydrocele. A hypodermic needle of small caliber is detached from its syringe and inserted in the top of the sac, while a larger aspirating needle is inserted near the bottom. It is well to approximate the points of these two needles so as to be sure that they are both in the same cavity. The entire contents of the sac is now aspirated, every endeavor being made to empty the cavity to the last drop. When it is thoroughly emptied, a syringe is attached to the hypodermic needle which has been left in its original position, and from 1 to 2 cc. of pure phenol injected into the sac, followed by massage of the scrotum to insure distribution of the acid. The needle should be immediately withdrawn and care exercised to prevent any of the acid coming in contact with the adjacent surfaces. If such an accident occurs however, the skin should be immediately wet thoroughly with alcohol to prevent burning, and a supply of alcohol should be on hand for this purpose. No anesthesia is required for tapping, as the pain is very brief and not severe. The sac usually refills somewhat during the succeeding ten days but should resorb without further intervention. If it should fail to do so however, a second aspiration without injection may be advisable, but if the condition does not then subside, open operation will be necessary.

Spermatocele may be treated in the same way as hydrocele, using but one needle for both aspiration and injection. In obstinately recurring cases it may be necessary to lay open the scrotum over the cyst, and after the cyst has been exposed, to excise it, evacuate its contents and either apply phenol to the wall followed by alcohol, or to cut away the wall with scissors, hemostasis being carefully maintained and drainage provided for in the wound while suturing.[6]

Operation for Hydrocele.—Either local or general anesthesia may be used in any of the open procedures. The scrotum is clamped off and a high incision, 8 to 10 cm. in length, is made over the most prominent

portion of the sac, usually beginning over the external inguinal ring and following down along the course of the cord. When all the fluid has escaped, simple eversion may be performed. Andrews' "bottle operation," consists in delivering the testicle through the hole in the sac, which is then everted and left unsutured, the incision in the scrotum being thereafter closed by suture without drainage. Some operators sew the cut edges of the sac behind the cord, so as to make sure reinversion does not take place. This operation gives good satisfaction to the patient for there is little pain, the sac soon shrinks down making a short convalescence, and postoperative hemorrhage is uncommon. Unfortunately, literature contains a number of reports of unsatisfactory results from this procedure, as it is unsuited to hydroceles of long standing, and in any case is likely to be followed by recurrence.

FIG. 49

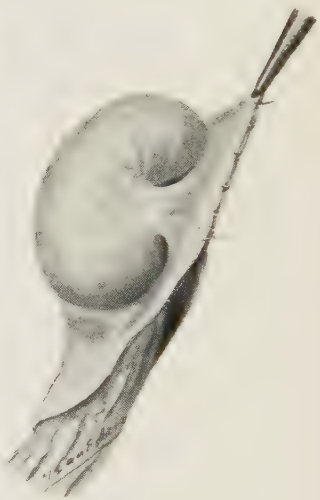

FIG. 50

FIG. 49.—Excision of hydrocele sac allowing sufficient flap to remain for the purpose of suturing it behind the epididymis.

FIG. 50.—Raw surfaces covered by suturing the cut edges together.

Winkelmann's Operation.—The skin and fascia are divided and dissected free from the tunica vaginalis; as much as possible of the parietal layer of the tunica vaginalis is then cut away, so that the testicle can be extruded from the scrotum. The sac is trimmed off to within ½-inch of its visceral insertion, and the cut edges are joined behind the testicle, making use of a continuous catgut suture. Care must be exercised to secure all vessels that might possibly give rise to hemorrhage later on. The wound should always be closed with drainage.

Amputation of the Scrotum.—Opinions vary as to the advisability of amputation of the redundant scrotum. If this is done, great care

must be exercised to suture the dartos separately from the skin, as sewing them together is a misadventure likely to happen if the dartos be allowed to slip up so that the needle penetrates both coats. Should this happen, hematoma in the scrotum will inevitably result. The skin should be reflected and the dartos picked up separately, No. 2 catgut being used for suturing the dartos, and horsehair or silkworm gut for the skin.[21]

Varicocele Operations.—Subcutaneous Ligation.—(A procedure originally devised by the elder Keyes.) Subcutaneous ligation can be profitably employed in the treatment of small varicoceles, or when one or two large trunks can be easily isolated. It requires a higher degree of skill on the part of the operator than the open method, as this last may be done under a general anesthetic so that a critical attitude on the part of the patient need not be considered, whereas subcutaneous ligation must be done in great part without anesthesia of any kind, and with the patient in the upright position in full view of the procedure. But as the dangers from suppuration and infection are reduced and the period of convalescence greatly shortened, it is well worth while for any surgeon to perfect himself in the necessary technic.

The patient is made to stand in order to distend the scrotal veins as much as possible. Each venous trunk is isolated from the others and from the vas deferens in turn. A silk ligature is passed through the scrotum on one side of the vein and carried around the other side of the vein, so that the ligature will enter and pass out through the same needle puncture in the dartos. On each venous trunk to be tied a ligature is placed, both above and below. "The requisite is a ligature of stout braided silk that cannot be broken by any pull the surgeon puts upon it," Keyes tells us; "no absorbable suture will obliterate the veins." Fuller however, says that the correct ligature to be employed is heavy twisted Chinese silk, braided silk not being recommended since it is more likely to loosen in being tied. The Keyes-Reverdin needle, especially designed for this procedure, has an eye opening from the handle. As each vein is tied all the others are held to one side by the thumb and index finger of the non-operating hand, pinching together the walls of the scrotum. When the needle has been thrust completely through the scrotum it is unthreaded so that one end of the ligature hangs in front and the other behind, the needle however, being left partly in the original puncture, so that it can be reinserted on the outside of the vein and made to come out posteriorly through the original hole. Thus when the end of silk hanging behind is threaded through the needle's eye and pulled to the front and through the original puncture, the vein will have been completely encircled.

The patient should now be placed upon the table and usually will need to be slightly anesthetized, as tying the ligatures is the really painful part of the procedure. The upper ligature should be tied last, in order not to leave the veins distended, and the first tie upon each should be as tight as possible, so that it will not only stop all circulation,

but also by trauma, and the effusion that will result from it, bring about complete obliteration of the veins. It is better to make three knots in each suture cutting the silk off close to the final tie. All scrotal tissues should be carefully pulled away from contact with the ligatures. For several days there will be considerable swelling and the patient should be kept in bed for about a week, and should wear a proper suspensory until all evidence of scrotal inflammation and reaction has disappeared.

Open Operation.—Open operation for the cure of varicocele has been variously accomplished by different operators. A precedure which is claimed to do away with the possibility of postoperative induration, is carried out as follows:[31]

An incision is made over the inguinal canal as for herniorrhaphy, dividing skin, Camper's fascia, Scarpa's fascia and the aponeurosis of the external oblique muscle, opening into the external ring. The cremaster muscle with its fascia is next divided and retracted, exposing the spermatic cord enclosed in the thin infundibuliform fascia. The part of the spermatic cord first seen is the anterior group of veins which are varicose, and which constitute the bulk of the varicocele. These are picked up at the internal ring and freed from the infundibuliform fascia as far as the testicle below. During this maneuver, the anterior veins are drawn away from the posterior veins and vas, so that there is no occasion to disturb the vas, nor even to touch it, thus avoiding any postoperative swelling from irritation of this organ.

The tortuous veins in front, having been freed, are ready for ligation, the ligatures being applied at the testicle below, and at the inguinal ring above. Using No. 1 plain catgut, threaded in an aneurysm needle, the mass of veins is transfixed close to the testicle, and the suture is tied on both sides of the mass. A clamp is applied to the vein mass proximal to the ligature in order to prevent soiling of the field with blood from the veins when divided, and division made between the ligature and the clamp. In similar fashion, the two veins at the internal ring are transfixed and ligated, care being taken not to include the little pouch of peritoneum which appears in front when the veins are freed close to the internal ring. A second ligature should be applied close to the first in case it should fail to hold. A clamp is placed on the vein mass distal to the second ligature, and the veins divided between it and the clamp, so that the mass can be removed from the field. The cremaster muscle with its fascia is now sutured snugly down to the vas, this being accomplished by passing the sutures at a distance from the cut edges. The retracted ilio-inguinal nerve is now replaced, and the incision in the external oblique aponeurosis is closed. Scarpa's triangle is closed as a separate layer and tacked down upon the external oblique aponeurosis, thus obliterating the dead space that would otherwise exist between the two layers, and also approximating the cut edges of Camper's fascia and the skin. The skin is closed by interrupted sutures of silkworm gut. After the dressing has

been put on, a suspensory bandage is applied to the scrotum to elevate it over the pubis, thus counteracting gravity. The patient can usually be up in two or three days.

Other operative procedures upon the scrotum are those for gangrene or abscess formation, which have already been described under their respective heads. In general, the operative treatment consists of free incision and drainage, with strict asepsis, depending upon the regenerative powers of the scrotal tissue to take care of the ultimate result.

NON-SURGICAL TREATMENT ON THE SCROTUM.

Support of the Testicles.—In all pathological conditions affecting the scrotum and its contents, proper bandaging and support is of the utmost importance, and all operative intervention is likely to be defeated in its purpose unless the supposedly minor matter of bandaging receives intelligent consideration.

In the authors' urological service, an adhesive compression bandage is used following all scrotal operations, which they have found most effectual in preventing postoperative hematoceles. While in a general way it follows the recommendations of Cunningham, perineal straps have been added to it. A strip of adhesive plaster about 32 x 6 inches is used, in which is cut an inverted Y, half as deep as the strip is long, thus forming the perineal straps. The top of the bandage is divided equally into halves, and from the point of division the plaster is torn down for about 10 or 11 inches. To the perineal portion of the suspensory thus made, is fastened a piece of gauze, 4 x 8 inches in size, and tightly rolled, making a pad which holds up the scrotum so that it will not slip down between the bandage and the perineum. When the suspensory is applied, the scrotum is raised and the rolled gauze pad held against the perineum; the pad thus serves to sustain the weight of the testicle, so that it will not bear upon the cord. While one hand holds this pad in place, the other applies the broad strips of plaster to the patient's abdominal wall, to which are later joined the perineal strips which are carried about the legs so that they lie in the gluteal folds.[7] Such a suspensory, if put on intelligently, will do a great deal to lessen postoperative complications and make convalescence less tedious.

Non-surgical Treatment of Scrotal Injuries.—In many traumatic conditions, as has been suggested for acute hydrocele or hematocele, rest in bed, the use of a proper suspensory and the application of an ice-bag to the affected area, will be all that is required to restore the scrotum to its normal condition. There is perhaps no part of the body which responds more readily to palliative treatment if intelligently and properly applied. Heat is not so frequently useful as the cold applications, but finds its best employment in acceleration of the circulation when this is desirable, as in promoting the absorption of hematoma.

Roentgen-ray, Violet Ray, Etc.—In many skin affections as manifested upon the scrotum, such as eczema, erythema intertrigo and pruritus, roentgenological treatment has proved very effective, and violet rays have also been used in these conditions. Of late years the use of the Alpine light has become very effective in treating sluggish wounds of the scrotum, more particularly those of tuberculous origin.

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CHAPTER VII.

TESTICLES, EPIDIDYMES, VASA DEFERENTIA AND SEMINAL VESICLES.

ANATOMY OF THE TESTICLES, EPIDIDYMES, VASA DEFERENTIA AND SEMINAL VESICLES.

Embryology of the Testicles. We have already seen that during the first few weeks of intra-uterine life the testicles develop in the abdominal cavity, posterior to the peritoneum, thus being covered by that structure only in front and at either side. When the end of the third month has been attained the testis is connected with the anterior abdominal wall by its mesorchium or epigonal portion of the genital fold; by the plica mesonephridica; by the plica inguinalis, and finally, by the crista inguinalis.[45] Within the fold thus formed there gradually appears, at first in separate parts, a cord of closely compacted, spindle-shaped cells, which extends from the location of the internal abdominal ring as far as the testicle. This cord is known as the *gubernaculum testis.*

As the fetus continues to grow the testicle is eventually surrounded by peritoneum and thus a mesentery is formed, composed of two folds, one above and the other below. It is in the upper fold that the spermatic vessels will eventually be located; the lower fold serves to convey the gubernaculum testis. As fetal development goes on the lower section of the gubernaculum grows larger, but above, on the contrary, degeneration and atrophy take place. A tube-like process has its rise in the lower section, formed of peritoneal substance, which extends into the peritoneal canal. This process has received the name of *processus vaginalis.*

Gradual descent of the gubernaculum and of the processus vaginalis now takes place until the base of the scrotum has been reached. Once here, the growth of the gubernaculum ceases, but as the fetal body is constantly increasing in size traction will be exerted upon the testicle sufficient to draw it downward. Atrophy of the gubernaculum shortly begins, and when the testicle has reached the scrotum the same fate overtakes the processus vaginalis, only a small portion in direct relation to the testicle surviving to form the *tunica vaginalis.* The upper opening of the processus vaginalis disappears, and of the processus itself there remains but a frail thread which may be traced along the spermatic duct where it mingles with the tissues forming the spermatic cord.

Origin of Hernia. - In certain cases the canal fails to close at all, or disappears only in part, thus giving rise to *congenital hernia*, for if

this peritoneal pouch remains open the tunica vaginalis has a free communication with the general peritoneal cavity.

Descent of the Testicles is normally complete about the seventh month of gestation. Interference with development, from whatever cause, may bring to bear influences which will retain them in the abdominal cavity or within the inguinal canal. When this occurs we have the condition known as *cryptorchism.*

Origin of the Seminal Vesicles.—The seminal vesicles originate about the thirteenth week of fetal life, appearing in embryos of that age as an invagination lateralward from each vas deferens, and covered by the same tissue which envelops these structures. The seminal vesicles grow backward and laterally, at this period consisting of a main part which is convoluted and from which rather numerous short branches, also convoluted, are thrown out in the manner described by Pallin.[96] In the further development of these structures the opening into the ejaculatory ducts becomes comparatively smaller and its component parts become larger and more tortuous. In a fetus thirty weeks old they were found beneath the middle part of the trigonum vesicæ, communicating with the vasa deferentia deeply in the base of the prostate, thus forming the ejaculatory ducts. At birth the ends of the seminal vesicles will be found to have extended back almost as far as the base of the trigonum vesicæ, and four branches from the main lumen of the organ can be made out. Its walls, composed of fibrous and muscular strands, are almost as thick as those of the ejaculatory ducts.

The Ejaculatory Ducts.—The ejaculatory ducts are the continuation of the vasa deferentia below the entrance of the seminal vesicles. Early in fetal life they are of comparatively large size but gradually become smaller in relation to other surrounding structures as development continues. They pass obliquely through the posterior wall of the prostatic urethra, accompanied by the utricle and the surrounding stroma layers, the outer fibers of which attach this cylindrical mass intimately to the urethral wall by intermingling with the tissue forming it. As these structures approach the lumen of the urethra its floor is pushed up into a mound and its lumen converted from a triangular to a semilunar shape. This mound, called the *verum montanum,* is made up entirely of the ejaculatory ducts, the utricle and their surrounding envelopes, and below the point where these several structures open into the urethra, it gradually disappears, the stroma cells becoming intermingled with those forming the urethral wall.

Embryology of the Vasa Deferentia.—The vasa differentia remain comparatively large until about the sixteenth week of fetal life, after which their relative size is very much less. They descend behind the the posterior surface of the bladder, at this point being situated near the ureter on either side. Lower down they gradually approach each other, in the earlier stages of development being contiguous behind the middle of the trigonum vesicæ. In the lower part of their course

they increase enormously in size, so that at the point where they pass beneath the internal sphincter of the bladder, they form a larger mass, including their enveloping tissue, than do the origins of the ureters with the tissues surrounding them. At this point the lumina of the vasa deferentia will be observed to have widened considerably, giving evidence of the first appearance of the ampullæ.

At about the twenty-fifth week the vesicles and ampullæ have assumed practically their adult form, that is, in so far as their general outline and the arrangement of their sacculations are concerned.[133] At birth each seminal vesicle shows five lumina in its upper part, all communicating further down, the end duct finally uniting with the ampulla of the vas deferens to form the ejaculatory duct.

Anatomy. Normally, at birth, the testicle hangs suspended in a cavity known as the *cavum vaginale*, separated from it, however, by the vesical layer of the tunica vaginalis. This vesical layer continues over the epididymis as far as that body's lateral border, at which point it is reflected forward so as to become the parietal layer. The difference in the extent of these two layers is sufficient to permit the formation of the cavity. The *tunica albuginea*, a capsule of thick fibrous tissue, encircles the testicle, being prolonged inward in such a way as to divide the testicle into lobes, each lobe containing a certain number of seminiferous tubules. These tubules have no outlet at the base of the lobe, but at this point extend toward the apex of the lobe, where they coalesce to form the *tubuli recti*. These in turn go to make up the *rete testis*, from which spring a dozen or more efferentia, and these efferentia, piercing the tunica albuginea, pass backward into the ligamentum epididymis superioris, finally becoming, in the globus major, the *coni vasculosi*. Here arises the epididymal canal, which at the cauda takes on the function of the duct of the vas deferens.

The epididymis, although generally referred to as a separate organ, is actually a part of the testicle proper, impinging upon its posterior border. Its origin is at the point where the vasa efferentia pierce the tunica albuginea. These canals, as has already been explained, become the coni vasculosi and go to form the *globus major* or "head" of the epididymis, that is, the section of it contiguous to the top of the testicle. The body of the epididymis is formed by the canal into which the coni vasculosi empty, and this is divided from the testicle proper by the cul-de-sac of the tunica vaginalis. Its lower point of union with the testicle is termed the *globus minor* or "tail" of the epididymis, and from this point it continues as the vas deferens.

Double-ply folds of serous membrane unite the epididymis to the testicle at three different points, this membrane being actually but a continuation over the epididymis of the tunica vaginalis's vesical layer. *Ligamentum epididymis superioris* is the name applied to the globus major fold, between the two leaves of which pass the vasa efferentia. At the body of the epididymis a space termed the *saccus epididymis* is enclosed by a double fold which constitutes the second

attachment, while the caudal end is touched by the *ligamentum epididymis inferioris.*

Morphological Rests.—Attached to the testicle proper and to the globus major are two small bodies known as the *hydatid of Morgagni* and the *paradidymis* or *organ of Giraldes.* In many individuals the hydatid of Morgagni is absent, but when present will appear as a pedunculated sac from $\frac{1}{8}$ to $\frac{1}{3}$ of an inch in length, its free extremity dilated and containing a colorless fluid. The organ of Giraldes lies above the lowest portion of the spermatic cord, immediately over the head of the epididymis. It looks like an irregular patch perhaps $\frac{1}{5}$ inch in diameter. These structures are of interest chiefly because they not infrequently give rise to cystic tumors, or to spermatocele, as described in a previous chapter.

Growth of the Testicle.—Until the age of puberty is attained, the testicle remains very small. Then, as do the penis and prostate, it undergoes a period of very rapid development, except in those cases where its descent has been arrested from any cause, or where varicocele has developed before the age of puberty.

The vas deferens, the duct draining the testis, is a continuation of the epididymis, extending from the globus minor to the posterior urethra. It enters the abdominal cavity through the internal abdominal ring, passing in as a part of the spermatic cord. At first it lies to the outer side of the deep epigastric artery, but farther on it will be found in the extraperitoneal fat, anterior and internal to the exterior iliac vessels and obliterated hypogastric artery; thence passing into the pelvis at the side of the bladder. It takes its course downward and backward upon the side of the bladder to its base, running between the bladder and the ureter, and from that point internal to the ureter. It passes along the inner side of the seminal vesicles between the base of the bladder and the rectum, now taking the form of a dilated tube or ampulla, which contains pouches or *sacculi.* Opposite the base of the prostate its lumen suddenly contracts, soon joining the open end of the seminal vesicle to form the ejaculatory duct;[37] this common tube descending to pierce the prostatic fissure and open into the prostatic portion of the urethra.

Seminal Vesicles.—External to the ampullæ of the vasa deferentia between the bladder and the rectum lie the seminal vesicles, which are, as has been noted in describing their fetal development, irregularly lobulated upon their surfaces, and often varying in size and shape, even upon the two sides of the same individual. The enlarged convoluted end of the vas deferens rests upon the inner side of each vesicle. Within each organ there is a central tube, 8 to 12 cm. in length, with two or more lateral branches. The tube is about the width of a goose-quill, presents several blind branches or diverticula, is closed at its upper end, and opens below into the ejaculatory duct. The seminal vesicles are surrounded by an envelope consisting of three layers posteriorly and two layers anteriorly or toward the bladder. These

coverings assume considerable importance to the surgeon who must make his incision entirely through the posterior coverings in order to properly enter the sac containing the seminal vesicles.

PHYSIOLOGY.

Development of the Spermatozoa.—Before the age of puberty is attained the seminal tubules contain cells the nuclei of which are of comparatively large size. At the adolescent period certain of these cells develop into *spermatocytes,* from which, after several other metamorphoses, the adult *spermatozoa* are formed. When this transformation is complete the spermatozoa migrate to the epididymis where they become motile; thence they progress to the vas deferens where this power of movement is still further developed; this tube being able to greatly facilitate their progress by its peristaltic contractions, as well as by the action of the cilia-like appendages of some of its lining cells.[15]

The Seminal Fluid.—We have already seen that the vas deferens receives a duct from the seminal vesicle, thereafter becoming the ejaculatory duct. The lining mucosa of the seminal vesicle contains albuminous glands which contribute a secretion to the semen, a secretion largely composed of globulins and having a mucoid stringy consistency. According to Burton-Opitz, since the semen becomes more fluid upon standing, the addition of these globular masses by the seminal vesicles merely serves the purpose of giving a greater volume to the fluid. In fact, in some animals this material is made to clot through the agency of a ferment derived from the prostate gland.

The seminal fluid thus consists of testicular secretion into which motile spermatozoa have migrated, later modified by additions of secretion from the prostate, seminal vesicles, and urethra in its passage through the genital canal. The fluid is mucilaginous in consistency, its specific gravity being usually about 1.033; of a grayish color; and giving off a very characteristic odor which is contributed by the spermin contained in the secretion from the prostate. During the period of virility, the secretion of this fluid constantly goes on, and it is stored up in the seminal vesicles and in the twisted portion of the vas deferens which adjoins the vesicle.

Ejaculation.—The discharge of the semen begins by a powerful peristalsis of the vas deferens, seminal vesicles and ejaculatory duct which forces the secretion into the urethra. The sphincter vesicæ contracts so as to completely block the passage of the fluid into the deeper urethra. At either side of the *colliculus seminalis* is a hollow which receives the secretions from Cowper's glands and the prostate, which are thus mingled with the seminal fluid as it passes through the urethra. The ischio-cavernosus, the bulbo-cavernosus and the sphincter of Henli, with certain other striated muscles, now begin a series

of involuntary rhythmic contractions, though the actual act of ejaculation is a voluntary one, controlled by a reflex center which is situated in the lumbar segment of the spinal cord.

Nerves.—Among the nerves which influence erection and ejaculation are the nervus pudendus, nervus erigens and nervus ileo-inguinalis. The first of these sends one of its branches—the nervus perinei—to the ischoid bulbo-cavernosi, the bulbus urethræ and to the mucous membrane of the upper urethra. This nerve is therefore, the one which controls ejaculation.[15]

Internal Secretion.—The extensive investigations into the subject of endocrinology which the past decade has witnessed, has placed at our disposal data which goes to show quite conclusively that, beside its generative function, the testicle has also a very great importance as a gland of internal secretion. Pézard's experiments upon cocks,[98] together with those of Gley, of Massaglia,[87] and other recent workers, would seem to have established beyond controversy that the testis has an internal secretion which gives to the male the masculine sex characteristics and instincts, as well as regulating the function of the hypophysis. This is well shown by the changes that come in the secondary sexual characteristics and in the pituitary body after castration, and by the fact that these changes do not come when there remains *in situ* or in the peritoneal cavity some part of the testis in functional condition.

By carrying out experiments upon birds who had reached full maturity of their sexual powers, Pézard demonstrated that the continuity of the endocrine function of the testicle is an indispensable condition for the maintenance of sex characteristics. By periodic measurement of the comb it was determined that immediately after ablation of the testicles retrogression in virility begins. This was also evidenced by loss of voice and of male pugnacity in castrated cocks.

The production of this internal secretion necessary to the development of secondary male characteristics is usually conceded to take place in the interstitial cells of Leydig which compose a certain portion of the testicle. If these cells are examined they will be found to contain granules and peculiar crystals giving them the appearance of true secretory elements, and it is possible that these bodies may be the precursers of this characteristic male hormone.[15]

ANOMALIES OF THE TESTICLES.

Hermaphrodism.—True hermaphrodism would be the presence of functionating generative organs of both sexes in the same living body. We know of no reports of such a condition ever being found in a human being. Very rarely cases are reported where the sexual glands of both male and female have been found in the same individual, but in none of these have all the organs possessed generative powers. In a case not long ago reported from Denmark,[107] a child, aged ten

years, presented labia majora, very small labia minora, a vulva and a much hypertrophied clitoris, 5 cm. long. A little behind this was the urethral orifice. The child's general physical appearance and outward conformation resembled that of a boy, but although appearing very intelligent, the psychic traits of both boy and girl were in evidence. Exploratory laparotomy showed a small uterus and a Fallopian tube with fimbriated end at each side. Upon the right side there was a testis-shaped body, at the left a somewhat larger body which had the

FIG. 51.—Hermaphrodite (male type). One labia majora is similar to the female, the other looks as though it were a part of the scrotum containing a testicle.

appearance characteristic of an ovary. Microscopic examination of small sections of excised glandular tissue showed the body at the right to be a testis of typical fetal structure; that at the left presented some of the elements of fetal ovarian structure. The difficulties of the urologist who is called upon to decide the sex of such an individual are readily apparent.

Pseudo-hermaphrodism.—This anomaly, while by no means common, is not so rare as that just described. In Cullen's case[30] the

patient's general appearance inclined to the masculine type and an organ suggesting a penis was present. The urethra however, was

FIG. 52.—Probe in urethra of case of pseudo-hermaphrodism (male type).

distinctly of the female type and there was a vagina in normal position into which the finger could enter for $1\frac{1}{4}$ inches, although it ended in a

blind pocket with no evidences of a cervix uteri. Operation upon a right inguinal hernia which was present, showed the sac to contain a testicle and a portion of the epididymis, while careful search of the abdomen failed to reveal any trace of uterus, tubes or ovaries. On the left side a testicle could be clearly made out in the upper part of the inguinal canal. On histological examination the testicle showed some minor changes. The gland epithelium was swollen, the cells closely suggesting the large squamous epithelial type; there was no evidence of spermatozoa. The stroma of the testicle was increased in amount. The epididymis was little altered.

A patient at Bellevue, supposedly a woman and engaged to be married, was operated upon for hernia. In the sac a well developed testicle and epididymis were found. Some years later a hernia developed upon the other side, which also contained a testicle and epididymis.

In the ten-year-old patient whose condition was reported by Quinby,[99] the external appearance was that of a boy aged about fourteen years. The services of the surgeon were sought on account of hypospadias and undescended testicles. The external genitals were of the male type and there was no evidence of a vagina, yet a search for the supposed testicles revealed no trace of a spermatic cord in the inguinal canal, and in the abdomen was found an infantile uterus with attached tubes and ovaries of normal appearance. Therefore, despite greatly predominating male secondary characteristics, this individual was of the female sex.

Hypospadias was also present in the case reported by Young and Cash.[142] The urinary meatus was at the peno-scrotal junction, the scrotum contained neither testes nor cords, and was bifid in character. Autopsy showed that on the right side just below the kidney there was a non-functioning undescended testicle, continuous with which was a well-defined epididymis. The epididymis persisted as a group of anastomosing tubules, which converged on the right posterior wall of the bladder to form one larger duct which was assumed to be the vas deferens. No trace of seminal vesicles was found.

Imperfect Descent of the Testicles.—As we have already seen, the testicle may be arrested at some point in the line of its normal descent during the intra-uterine period. If it is retained entirely within the abdomen the condition is termed *non-descent;* if the gland is stopped just below the external abdominal ring, we use the designation *partial descent*; while by *retention of the testicle* we indicate that it has not reached the bottom of the scrotum but is retained in its upper part.

Ectopia.—Sometimes the testicle will descend as far as the outlet of the inguinal canal and at this point will deviate to some abnormal position, most commonly to the perineum, though these aberrant glands have been found at the peno-scrotal junction, in the upper part of the thigh, or even toward the anterior-superior spine of the ilium on the superficial surface of the aponeurosis of the external

oblique muscles of the abdominal wall.[43] Such abnormal descent is termed *ectopia.*

Etiology.—There are apparently only two factors operating to produce abnormal descent of the testicle. In the first certain fibers of the gubernaculum testis may have exerted an unusual tension upon it in such a way as to divert it from its normal line of descent; and in the second place, the advance of a hernia may have pushed it into

FIG. 53.—Partial descent of testicle. In this case the gland is drawn tightly up to the external abdominal ring. This is a very bad place for the testicle to be as it is particularly exposed to traumatism.

an anomalous position. It is well established that such a sequence of events may take place, and this probably explains most of the cases where the testicle has been found superficial to the inguinal canal. As the gland advances into its abnormal position it carries before it a process of the peritoneum, thus forming a pouch which may remain in communication with the general peritoneal cavity, in which case it forms the *process vaginalis,* or, when communication is cut off, the *tunica vaginalis.*

Function of the Ectopic Testicle.—It is generally recognized that a testicle which has been arrested in any part of its descent is incapable of performing its normal function, at least in so far as the formation of spermatozoa is concerned. However, conspicuous exceptions to this rule have been noted; microscopic examination of semen ejaculated from testicles which had been retained as high up as the abdomen, in the canal, or just below the external ring, has proved that it may contain motile spermatozoa; and well-authenticated cases are on record where double cryptorchids have become fathers.

Familial Occurrence.—The question of heredity in its influence on the production of anomalies has of late years received little attention, but the comparatively frequent occurrence of undescended testicle and the abnormalities which often accompany it deserves passing notice. A report was made not long ago[26] concerning a family of six sons of the same father and mother, in every one of whom some testicular anomaly was present. The father's testicles were both fully descended, and the mother was without any developmental anomaly; a more extended family history could not be obtained. A number of similar reports are to be found in earlier literature.

Development of the Ectopic Testicle.—Even in those cases where the testicle wanders from its course into the perineum, it may be a fully developed organ, although a condition of atrophy is much more common. However, if the gland lies in front of the aponeurosis of the external oblique muscle of the abdomen, in Scarpa's triangle, or at the root of the penis, it will not usually attain functional ability. Non-descent of both testicles is practically always associated with lack of development elsewhere in the genital tract, and as a rule an individual displaying this anomaly will be absolutely sterile, though probably perfectly potent.

It would appear therefore, that that part of the gland, commonly supposed to be the interstitial cells, which influences the development of secondary sex characteristics, functions quite as well in its anomalous situation as it does when properly located in the scrotum.

Advisability of Operation.—A testicle retained at birth may descend spontaneously during infancy, and it is generally recommended that efforts be made to effect this by means of massage and gentle pressure, as from a truss. Should this prove unavailing operation is advisable, for the undescended testicle is little prone to function, and in its anomalous position is much more liable to suffer trauma, to undergo torsion, or to become the site of a malignant neoplasm. Hernia, too, is very likely to occur.

Hernia.—In the normal descent of the testicle into the scrotum it passes, as we have already seen, through a tube of peritoneum, the processus vaginalis, this tube closing up when descent is completed. But when the testicle's descent is arrested, or if the gland is undersized or poorly developed, the processus vaginalis remains patent, so that very frequently when a more or less defective testicle is present in its

normal position, certain of the abdominal viscera will be found to have prolapsed into the tube. The peritoneal process associated with an undescended testicle very often has also a larger lumen than is found when descent has taken place normally, a fact which probably accounts for the greater frequency of *torsion* of the spermatic cord under these conditions.

Congenital Inguinal Hernia.—Congenital inguinal hernia probably occurs in 50 per cent of the individuals in whom there has been arrest of the testicle. It is likely also that there is associated with it some failure of development of the muscles of the lower abdominal parietes, so that a number of different anomalies work together to produce the hernial condition. The majority of the cases of inguinal hernia associated with imperfect descent of the testicles, are manifest early in life, which would indicate that in infancy special exciting causes may be at work to produce it. No less than 35 per cent of herniæ with arrest of the testicle occur in the first year of life, while in inguinal hernia in those who are not afflicted with imperfect descent of the testicle, only 7.7 per cent commence before the end of the first year.

Inguinal and abdominal inclusion favor the early development of a hernial protrusion, while the testicle, lying just below the superficial abdominal ring and high in the scrotum, does not have an accompanying hernia so soon under ordinary conditions. But it must always be borne in mind that the subjects of partial descent of the testis may exhibit a hernia at any age.[105]

Associated Hydrocele.—Congenital hydrocele and hernia frequently occur together, and the presence of hernia greatly decreases the likelihood of spontaneous cure of the hydrocele. *Inguinal hydrocele* is very infrequently observed surrounding an undescended testicle.

Torsion of the Testicle.—Though torsion of the testicle may occur when normal descent has taken place, it is much more frequent in those subjects in whom the testicle has failed to descend. Abnormal length of the mesorchium—the peritoneal fold which retains the fetal testicle in position—or its practical absence, may induce torsion, or a congenital twist of the cord may exist. Again, as already seen, the tunica vaginalis may have an abnormally large lumen, or the arrested testicle may be flattened and misshapen, which makes it more liable to twist.

Torsion of Normally Situated Testicle.—Abnormal attachment of the common mesentery and vessels to the lower pole of the testis and to the globus minor, so that the gland instead of having a broad band for an attachment is connected merely by a narrow stalk, is a condition often described as anatomically favoring torsion of the fully descended testicle. Elongation of the globus minor or too wide a lumen to the tunica vaginalis, may also contribute to produce it.[41]

Another explanation is that faulty development has resulted in an internesorchial separation of the cord, so that the testis is more horizontally placed, the effect of this being that the descending globus major draws the vessels away from the vas deferens.[127] A very rational

explanation was put forward in Germany a few years ago, namely, that torsion is always brought about by contraction of the anomalous cremasteric fibers, in conjunction with abnormal attachment of the testis, a certain deficiency in the make-up of the gubernaculum associated with an unusually capacious tunica vaginalis.

Etiology.—Although the immediate exciting cause of torsion of the testicle is usually given as straining or other violent muscular effort, the injudicious application of a truss may have the same effect, and some cases have been recorded where torsion occurred during sleep.

Pathology.—In proportion to the extent to which they have been occluded by the twisting of the cord, the spermatic veins above the point where the twist has occurred will be distended, flattened or partially obliterated. The spermatic artery, however, though always much distended, will usually be found pervious. The extent of the twist varies from one-half turn to two full turns, and the site of the twist is always in that free portion of the cord which, covered by tunica vaginalis, suspends the epididymis and testicle.[95] A small amount of fluid will usually be found in the tunica vaginalis; straw-colored if the case be seen early; but when some time has elapsed between the occurrence of the torsion and operative intervention, bloody, or as dark as prune juice.[85] The twist is always intratunical, between its attachment to the testis and the reflection from it of the tunica vaginalis, but one case, that of Taylor in 1897, having ever been reported otherwise. The twist may be in either direction, although from within, outward and forward, seems to be more common.[23]

On section the parts show intense engorgement, being red, blue or black depending on the duration of the condition. In the longer standing cases there is a destruction of the testis, not a necrosis in the ordinary sense of the word, but an aseptic death of the gland, which in process of time undergoes fibrification and consequent atrophy if left in the scrotum. When the condition of torsion recurs, a hydrocele usually forms in the scrotum and adhesions will form also, thus anchoring the testicle. The microscope may reveal hemorrhagic infarction, or a diffuse interlobular hemorrhage.[95] The condition most commonly occurs about the age of puberty.[7]

Symptoms.—The symptoms are in the main those characteristic of epididymitis, for which the condition is often mistaken. It may also be confused with strangulated inguinal hernia or incarcerated omental hernia. The shortening of the cord by the twist gives the scrotal contents the appearance of being pulled up into the groin, and this, together with the marked edema extending across the septum and a mild degree of tenderness compared with that encountered in acute infections of the scrotum, are the points which must be relied on for differentiation.[85] Nausea and vomiting may or may not be present so that they are of little if any diagnostic aid. The redness of the scrotum, the elevation of the testis, and the limitation of the swelling to the lower inguinal canal are all important.[95]

Treatment.—The testicle has, in a few reported cases, been successfully rotated back into its normal position, thus untwisting the cord. Detorsion should only be attempted in those cases which are seen early, and where the testis is *outside* the external abdominal ring. It is obviously impossible when the condition is of sufficiently long standing for the testicle to have become engorged and a large hydrocele to have accumulated in the tunica vaginalis. In the majority of cases either orchidopexy or orchidectomy will have to be performed.

ABNORMALITIES OF THE EPIDIDYMIS.

Although the epididymis is properly a part of the testicle, it may yet present separate anomalies which will have a bearing on the development of the individual. Sometimes the epididymis will be so large in relation to the size of the peritoneal tube, through which it should descend to the scrotum, as to render this descent impossible. Again, cases have been recorded where the body of the testicle was arrested in the inguinal canal, although the vas deferens and epididymis descended much below it, so that they could be palpated completely outside the canal. It should be emphasized in this connection that the vessels conveying the blood supply of the testicle are wholly separate from those of the epididymis and vas deferens.

ANOMALIES OF THE SEMINAL VESICLES AND VASA DEFERENTIA.

Anomalies of the seminal vesicles and vasa deferentia are naturally largely dependent upon those of the testicle. Occasionally a testicle and seminal vesicle with part, at least, of the vas deferens upon one side, have been found lacking. Very rarely, the testicle has been found present, while epididymis, vas and vesicle were absent.

INJURIES TO THE SCROTAL CONTENTS.

Traumatic injury of the scrotum has already been discussed (page 181) and mention made of the conditions under which such wounds are likely to be inflicted. Though the testicles would at first thought, appear to be in a very exposed position, both these glands and the spermatic cords are so well protected by the scrotum which covers them, and are so freely movable in their suspended position that injuries to them are relatively unusual.

When trauma effects the testicle or epididymis the pain is excruciating and the patient usually sustains a degree of shock out of all proportion to the apparent gravity of the injury. Wounds of the scrotum alone do not produce such severe reaction and can by this means be readily differentiated. Lesions of the scrotal content may be classified as either *open or closed*,[6]

Open wounds include punctured, stab and gunshot injuries, as well as those wherein the scrotum and enveloping tunics have been torn and lacerated.

Closed wounds are principally contusions and dislocations. There may be *direct* trauma to the testicle and epididymis, or the injury may be *indirect* resulting in lesion of the spermatic cord, with damage or destruction of the bloodvessels, and laceration of the vasa deferentia and seminal vesicles. Torsion of the cord frequently takes place, usually with the sequel of gangrene or atrophy.

Gunshot Wounds of the Testicles.—Such wounds are quite frequently reported, and are naturally numerous in recent war literature. Frischer[49] gives an account of a case where the bullet passed through the left sorotal sac, cutting off the globus major and the upper part of the testicle, lacerating the left cord, and severing the vas deferens. It then passed through the right scrotal sac completely dislodging the testicle, the right cord being retracted into the inguinal canal. The lacerated left epididymis was removed and the other structures repaired, the patient eventually making a good recovery from his wounds and regaining potency. Three months later, however, no spermatozoa could be demonstrated in the semen.

In an injury reported by Thévenard[123] a bullet entered the external surface of the left thigh, passed out through the inguino-crural fold into the scrotum tearing it to pieces, lacerating the urethra and practically destroying both testicles. When seen seven days after being wounded at the front, the scrotum was hanging in ribbons and the débris of the testicles was rapidly becoming gangrenous. At each micturition all the urine flowed over the wounded area, and the perineum was edematous. Apparently no attempt was made to repair the damage to the testicles, for the author merely mentions that the scrotal wound cleansed itself while the testicular débris sloughed off, and that operation for the repair of the urethra was delayed because the patient contracted scarlet fever. Despite all this however, healing took place, and when repair of the urethra was later undertaken a fragment of the right testicle about the size of a hazelnut was found adherent to the urethral canal and left in its normal position. Examination of the repaired urethra when the soldier was about to rejoin his regiment showed that this testicular graft had apparently increased in size, despite which, however, the patient had taken on something of a feminine type. This case illustrates the remarkable regenerative powers of scrotal and testicular tissue following traumatic injury.

Relighting of Old Inflammatory Lesions. Two instances of wounding by shell fragments resulting in injury to the testicle followed by subacute orchitis are reported by Gaucher and his confreres.[51] The chief interest in these cases lay however, not in the extent of the traumatic lesions so much as in the subsequent inflammatory condition which was out of proportion to the severity of the injuries. A care-

fully elicited history finally revealed a previous gonorrheal epididymitis which the testicular trauma had served to relight. This possibility is of especial importance to industrial surgeons and those engaged in insurance work.

Closed Wounds of the Testicle.—The great majority of closed wounds to the testicle and epididymis are sustained by horsemen, either from kicks, or violent contacts of various kinds while astride the animal's back. It would seem, therefore, that the increasing use of automobiles ought to lessen the incidence of this particular class of injuries.

The immediate effect of kicks is intense swelling and edema of the scrotum, often with ecchymosis and great pain, radiating from the testicle to the thighs and the abdominal region. If palpation can be endured, the testicle will usually be found more or less enlarged. The swelling and congestion will increase for several hours, then gradually subside, being limited to a certain extent by the inelasticity of the tunica albuginea. The firmness of this unyielding tegument tends to make the pain more intense, and its compression adds to the damage already sustained by the testicles. Some authorities even recommend incision of the tunica albuginea for the relief of pain and to lessen the likelihood of atrophy as a result of the compression. When the acute symptoms subside sclerosis often follows upon cicatrization and the final outcome is complete atrophy of the gland. Such a condition has been described by Churchman[22] who removed a testicle which had shrunk until it reached the size of a hazelnut following a kick inflicted eleven months before. Section of the testicle showed a good many normal tubules and a few atrophied ones. There was no connective tissue increase. The vas and epididymis were patent and no good pathological explanation was found for the atrophy.

Explosive Rupture of the Testicle.—Explosive rupture of the testicle from trauma is reported by Cotton[27] whose patient while witnessing a baseball game was struck in the scrotum by a batted ball. The swelling and discoloration were very great, and as he had previously suffered from a left-sided varicocele, a diagnosis of rupture of the varicocele was made. Operation disclosed a mass of blood clots and when these were cleared away it was found that nothing was left of the testis but shreds adherent to the tunica albuginea. It had evidently exploded under the impact as a full bladder bursts under a blow. The epididymis showed but little damage and the cord was undamaged save for rupture of some of the varicose veins which bled moderately.

Dislocation and Luxation of the Testicle.—Dislocation and luxation of the testicle are mentioned in lately published text-books, but as we have been unable to find any examples of such results from trauma in the literature of late years, it would seem to indicate that such occurrences are very rare. Keyes quotes Bruns (1884) as recording the case of a man run over while lying on his back, so that the right testicle was dislocated over the pubis at the root of the penis. Smith, in

Cabot's *Modern Urology*, mentions cases collected by Nicholas (1899) where the testicle was driven to the side of the penis, over the pubis and into the groin. Chetwood records a case coming under his own observation where a butcher, lifting a heavy hind of beef, retracted his testicle, an undeveloped gland, into the inguinal canal, where it remained.

A dislocatable testicle was reported by Frederick in 1912.[48] When the patient first presented himself for examination a medium-sized swelling was observed, apparently a large hernia which had not passed the external ring. It was found possible, however, to reduce this hernia into the scrotum, where it proved to be a testicle freely movable with a normal length of spermatic cord. When the scrotum was relaxed, the testicle had free movement up to $1\frac{1}{2}$ inches from the external ring. Incision showed the spermatic cord's sheath to be widely distended almost like a hernial sac, and the muscular coverings were very weak. By narrowing the external ring, escape of the testicle was rendered impossible.

Treatment.—Treatment of wounds of the scrotal content is directed toward the immediate reduction of the acute symptoms, along the lines laid down for the treatment of scrotal injuries (page 182). If the shock is severe, as is usually the case, the routine supportive measures for combating this condition must be put in practice, all attempts at palpation or other examination being deferred until the patient rallies, though severe hemorrhage must, of course, be immediately controlled. If herniation of the testicle takes place it should be reduced if possible, without loss of substance, and the torn envelopes carefully sutured. If the herniated tissue is very much lacerated and cannot be reduced, the surgeon should heed the wise admonition that while it may be snipped off with scissors it should in no case be pulled upon,[68] for in this way the entire gland may be drawn out, and a viable testicle thus needlessly sacrificed. Contusions may produce a typical orchitis or epididymitis, which must, of course, receive the treatment appropriate to these conditions.

Surgical Injury.—In operations for the radical cure of inguinal hernia, the vas deferens is occasionally injured, being divided when dissection of the sac is being carried out. This is especially liable to happen upon a little boy, as children have a very slender vas deferens.[63] The vas deferens in the infant is a thin white cord which may easily be mistaken for the margin of the hernial sac. Separation of the spermatic vessels and the cord from the hernial sac should be accomplished by traction upon the fascia on either side, thus avoiding injury to the structures themselves, as may happen if they are seized with the forceps. In young children the vessels are very small and easily traumatized, and if bleeding begins it is difficult to apply hemostats to such tiny lumina. Consequently several vessels of the cord may be included in the pressure forceps, and the vascular supply to the testicle considerably compromised.[94] Atrophy of the testicle has frequently followed both

the Bassini and the Halstead operative procedures, which Eccles believes has been due to interference with the blood supply of the cord.[42] In Mignon's operation for undescended testicles the spermatic vessels are ligated and severed, so as to permit a further descent of the testis. Hutchinson warns against the possibility of this maneuver causing atrophy of the testicle after it has been placed in the scrotum, quite justly observing that it is of no use bringing down the testicle if it is to waste away.

DISEASES OF TESTICLES AND EPIDIDYMES.

Tuberculosis of the Testicle.—Apparently no absolutely incontestable case of primary tuberculosis of the body of the testicle is on record. In 500 necropsy reports upon cases of pulmonary tuberculosis Reclus observed genito-urinary involvement in 12.8 per cent; in 3.8 per cent the involvement was confined to the testicle and epididymis. In a slightly larger series, 531 cases, studied by Fowler and Goodlea, 5.27 per cent were found to have involvement of the genito-urinary tract, and in 9, or 1.7 per cent, the testicle and epididymis were alone affected. A series of genito-urinary cases which came to autopsy showed the lesions of pulmonary tuberculosis in 67 per cent, and even in those individuals in whom no other tubercular foci can be found, it is apparently always the epididymis which is first affected.[82] But it would seem nevertheless, that the majority of patients coming for treatment for tuberculosis of the testicle and epididymis, do not have demonstrable tubercular lesions in other organs, and it would also seem that the existence of epididymal tuberculosis is not an index of a general genito-urinary infection.[5] It has been asserted on good authority however, that testicular tuberculosis is never an isolated lesion, that it is only one feature of a general genital tuberculosis, for sterility is frequent if not constant, at the time the first testis is invaded, and evidence of coincident inflammation of the internal genitals can usually be found.[67]

Uncertainty in Regard to "Primary Focus."—The whole question of the primary focus has been much disputed and is still in doubt. A very extensive study of the question was made by Sussig[118] who with Teutonic patience and thoroughness examined some 160,000 serial sections cut from the genitals of 30 men who had died from acute generalized tuberculosis. None of these subjects had during life manifested symptoms which had directed attention to the genitals, and in two-thirds the most minute postmortem inspection failed to reveal any involvement of these organs. But Sussig's observations upon the remaining 10 cases are of great interest and they offer strong evidence that when tuberculosis invades the genito-urinary tract it first finds lodgment in the vascular system. Moreover, his results would seem to indicate that no one genital organ can be fixed upon as the site of predilection, as practically every part of the male genital

tract may become primarily infected, and tubercular lesions may be found in every possible combination of these organs.

It would seem that, in general, tuberculosis of the male genital tract is more often multilocular than single.[44] The studies of several eminent American urologists have led them to conclude that in the great majority of cases the primary focus of genital tuberculosis is in the seminal vesicles, and that from the vesicles the infection spreads to the globus minor.[142] The discussion of this question is of much more than academic interest because for the intelligent and therefore successful treatment of any surgical ailment an exact knowledge of its pathology and mode of invading the various structures of the body is most important, for it is only by eradicating the primary focus of genital tuberculosis that we may hope for good results following surgical intervention.[101]

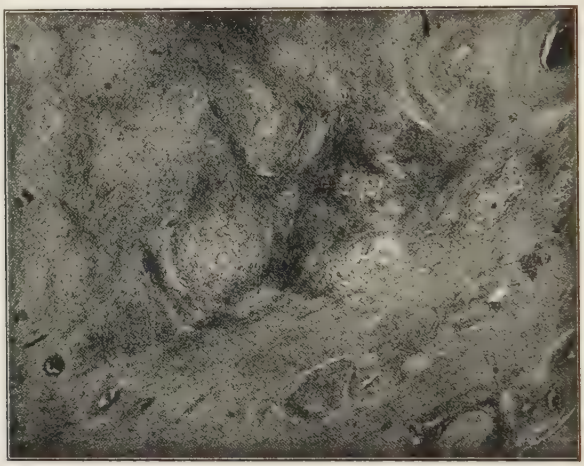

FIG. 54.—Photomicrograph of advanced tuberculosis of the epididymis. Many tubercles are clearly seen. There are numerous giant cells scattered throughout the field.

Pathology.—When genital tuberculosis is first brought to the attention of the practitioner in the great majority of cases the lesions will be in evidence in the epididymis, usually in the globus minor. Ordinarily it begins as a subacute process, practically painless, and existing for some time before the patient regards it as of sufficient importance to consult a physician. Not infrequently however, there will be an acute attack, simulating gonorrheal epididymitis, indeed, the demonstration of a mixed infection in such cases is not at all uncommon. The developing tubercles form hard masses which soon extend from the globus minor to the other parts of the epididymis and to the vas deferens which will be found lumpy and thickened. In certain cases it may remain quiescent for a long time (especially in the epi-

didymis) bursting forth now and again with surprising violence, all the while replacing the normal tissues of the organ by a process of caseation and cicatrization.[3] Hydrocele develops from the distention of the tunica vaginalis by fluid in the tubercles with which it is quickly studded, and as the process extends the scrotum becomes adherent to the testicle, a fistula soon opening through which the caseating material resulting from the breaking down of the tubercles will be discharged. The function of the affected organs is practically always destroyed, and should the process become bilateral, complete sterility is inevitable. Microscopically, the appearance is similar to that of a tuberculous process elsewhere in the body.

Symptoms and Diagnosis.—Most of the patients are in the third decade of life, seldom over forty-five or under fifteen years of age. There will usually be a history of some trauma or preceding gonorrheal epididymitis, and in the majority of cases, a personal or family history positive for tuberculosis, or at least, highly suggestive. Frequent and painful micturition is often mentioned. At times, however, there will be nothing whatever in the history which will serve to put the examiner upon the right track.

If the attack is acute there will be some pain and much swelling of the testicle, hydrocele soon becoming noticeable. But in the subacute process there will be only tenderness on palpation of the epididymis, no pain being experienced as a general rule; the epididymis will offer a lumpy sensation to the examining fingers. The vas deferens will likewise be found indurated and knotty, while rectal palpation will frequently show a similar condition in the seminal vesicle. These findings, together with the age and the pertinent facts in the history, are usually sufficient to establish the diagnosis.

Differential Diagnosis.—A tubercular epididymitis may easily be confused with an inflammation due to other causes. A systematic study of epididymal inflammations made recently upon material obtained in a large New York City clinic,[118] led to the following conclusions:

1. Double epididymitis found on examination slightly favors a diagnosis of tuberculosis.

2. A prior orchidectomy or epididymectomy almost invariably means tuberculosis.

3. A scrotal sinus of over a month's duration is probably tuberculous —but it may lead to a gumma.

4. A tubercular focus elsewhere in the body means genital tuberculosis in over 90 per cent of such cases.

If the scrotal swelling has been evident for a month or more, rectal examination will often be of service. If definite involvement of prostate and seminal vesicles can be established, there is every probability that we are confronted by a tubercular process.

Though a long slow process points strongly toward tuberculosis it must be kept in mind that inflammation of the epididymis due to other causes than the tubercle bacillus may be of extremely long duration.

Four of the 35 non-tuberculous patients included in the series just mentioned sought advice three years or more after onset of the swelling, while but 4 of the 74 who were incontestably demonstrated to be tubercular, gave a history covering an equal length of time.

Differentiation from Syphilis and Malignancy.—While the acute form of testicular tuberculosis may sometimes be temporarily confused with epididymitis due to other causes, a slowly progressive tubercular focus within the scrotum is not likely to simulate anything other than a tertiary syphilitic infection, or in very rare instances, a malignant growth.

A syphilitic process is never tender to pressure and practically always makes its initial appearance in the testicle, whereas tuberculosis will be first clinically evident in the epididymis. Careful examination frequently repeated will usually serve to establish differentiation. There is, to be sure, a very slight probability of tuberculosis and syphilis being coincident—a few such instances having been reported.[81]

Treatment.—The opinion of those most cognizant concerning genital tuberculosis are much divided as to the preferred method of treatment. Many authorities hold that the hygienic regimen advised for phthisis is equally useful when the genital tract is the seat of the lesion, and all surgical intervention should be avoided. The conviction is steadily gaining ground, however, that surgery offers the best hope of cure, and the recent improvments in technic have done much to demonstrate the wisdom of such a procedure. One of the best known American authorities on genital tuberculosis is so strongly in favor of operative measures that he has recently said: "If the evidence is in favor of tuberculosis, or if the disease is clearly progressing, an exploratory operation should be advised. The diagnoses of lesions within the scrotum are so uncertain, even when made by the most expert, that the patient should be given the benefit of the doubt. If he has tuberculosis he is entitled to the earliest treatment; if he has not tuberculosis he is entitled to the joy which that knowledge brings."[3]

Syphilis of Testicle and Epididymis.—The testicle may become involved at any point in the course of a syphilitic infection. The lesions are essentially chronic in type, the testicle proper being more often affected, through it has been stated on excellent authority that syphilis of the epididymis alone, without involvement of either the testicle or the spermatic cord, is not so rare as has formerly been supposed.[76, 88]

Pathology.—No matter what portion of the scrotal content is affected, the pathological findings will be practically identical. The histological picture has been thus described.[59]

In the active cases there exists a plasma-cell and lymphocytic infiltration between the tubules, a proliferation of the fibroblasts of the stroma with thickening of the basement membrane and decreased spermatogenesis. Such changes may occur diffusely or locally. In advanced stages of the disease the spermatogenic epithelium of the

tubules may be atrophied; spermatogenesis is therefore, absent. In some instances, however, part of these structures may be well preserved and properly functionating when the testes otherwise show marked pathological changes. The stroma between the tubules in the later stages becomes thickened and hyaline. In still more advanced stages the entire testis becomes fibroid. Grossly, the involved organ may be moderately enlarged, globular, indurated and smooth. In the later stages it is frequently fibroid, being then of smaller size and harder consistence.

Though clinically demonstrable in but a small number of cases, pathologically the testicles of practically every syphilitic may be said to be diseased. These pathological changes tend toward a progressive decrease of spermatogenesis, which may cause a premature loss of sexual desire and virility.

When gummata occur in syphilitic orchitis, which is relatively rare, the pathology is the same as that of gummatous processes in other parts of the body. The organ will appear enlarged and nodular, while adhesions to the scrotal tissue are commonly found. Often the nodules will break down and emit a caseous discharge likely to be followed by secondary infection and abscess formation, with eventually, the establishment of a large cratiform ulcer upon a sloughing base.

Symptoms.—*Sclerosis.*—The most common lesion of the testicle proper is sclerotic in form. The classic description compares the appearance of the sclerotic testicle to that of a billiard ball, enlarged, rounded, smooth, heavy and insensitive. Even severe pressure upon it will produce no normal testicular sensation, although the patient may complain of pain, probably caused by traction on the cord, or perhaps by distention of tissue unaffected by the luetic process, this pressure being exercised by the fluid which has collected in the vaginal sac. In the billiard-ball type, the epididymis is not often involved in the syphilitic process.

Epididymitis often occurs during the third or fourth month following the onset of the disease, concurrent with the cutaneous lesions. The most common manifestation is an indurated swelling of the globus major, not larger than a small bean, the condition being often bilateral. When the skin eruption subsides these swellings frequently disappear also, so that on physical examination the epididymis will not appear in any way abnormal.

During the active stage one or both epididymes will be found much enlarged and very hard, the hypertrophy being most noticeable in the globus major. The encased globus major has been designated by French urologists as the "helmet crest," this helmet sitting over the upper end of the testis much as the adrenal body rests upon the upper pole of the kidney. The diseased areas are thickened, irregularly indurated and somewhat nodular. The epididymis is easily outlined on palpation and is not adherent to the skin of the scrotum or to the testicles. The testis proper may be normal in size or slightly atrophied,

while a moderate-sized hydrocele may or may not be present.[59] This collection of fluid may be due only to the thickening of the tunica vaginalis and subsequent disturbance of the circulation, or it may be the transudate resulting from a chronic passive congestion. Fluctuation may be very indistinct because of the increased thickness of the tunica vaginalis, so that there may even be difficulty in outlining either the testicle or the tumor mass. On opening the hydrocele the layers of the tunica vaginalis will be found closely adherent and lined with a thick organized membrane, while numerous areas of slate-colored deposit have often been observed.[88]

Acute syphilitic epididymitis is sudden in onset, pain, which is greatly increased on walking or other movement, being always in evidence, and sometimes extremely severe. The swelling however, is not usually very great, and the surface of the affected organ is smooth and elastic, so that by palpation it can readily be differentiated from the testicle.

Chronic syphilitic epididymitis is most commonly a sequel to an acute infection, but at times it may develop slowly and painlessly, so that the patient is wholly unaware of anything abnormal until his attention is attracted to the swelling in the scrotum. At times, however, this hypertrophy will be accompanied by a dull dragging pain, felt along the inguinal canal and within the scrotum, and when the patient seeks relief for this the examiner will find the epididymis indurated and, if seen early enough, elastic on palpation. Later the epididymis will present a board-like rigidity, the process usually commencing in the globus major, but later involving the entire organ.

The chronic indurative type of syphilis of the testicle is the more common form. Subacute syphilitic epididymitis is most often seen during the secondary stage of the disease. Orchitis and epididymitis are frequently observed at the same time in the tertiary stage of syphilis although apparently it is the testicle which is first affected, the process later extending to the adjacent organs. In the sclerotic form extension is less likely to take place, the lesion remaining confined to the area where it originated. A gummatous process, which is a manifestation of the tertiary stage, usually involves the adjacent tissues, first by extension of the inflammation, and later by a process of ulceration. Sometimes it will be impossible to establish whether such a gumma first arose in the testicle or in the epididymis, as the entire scrotal content will be involved, testicle and epididymis being changed into an unrecognizable gummatous mass, while a hydrocele will have formed in the greatly thickened tunica vaginalis. Later cratiform ulcers are likely to occur, frequently eventuating in hernia of the testicle thus denuded of its covering.

Diagnosis.—Essential hydrocele was formerly a stumbling-block in the path of the examiner who was confronted by a luetic infection of the testicle, but at present no one would make such a diagnosis without an investigation of the scrotal contents sufficiently thorough to exclude

all possibility of pathological conditions in any of the contained organs. It is better to aspirate the fluid contained in the hydrocele, as its presence is a hindrance to complete examination.

Gonorrhea, carcinoma and tuberculosis, all of which frequently affect the testicle, must be ruled out. The first presents few difficulties as it is easily identified bacteriologically; moreover the process will be much more acute, and a concurrent gonorrheal urethritis usually is present to give confirmative evidence. Tuberculosis offers considerably more difficulty; some of the chief elements of confusion in differentiation have already been enumerated (page 227). If the process is malignant, the patient will be cachectic and the regional lymph nodes most likely involved. Sarcoma especially, grows with great rapidity, and while carcinoma does not advance so quickly, both give rise to pain practically always absent in luetic affections. A malignant process is less diffuse than a syphilitic one, usually remaining sharply localized until far advanced. The final test ordinarily rests upon the result of carefully taken Wassermann tests on both blood and spinal fluid, and the response to antiluetic treatment, under which the active lesions will disappear as if by magic, although full restoration of the affected organs is seldom possible.

Syphilis of the Vas Deferens and Seminal Vesicles. -The vas deferens and seminal vesicle are so seldom affected by syphilis that the possibility merits but passing mention. Thompson,[125] who made a careful survey of the literature, found but 13 possible cases of syphilis of the spermatic cord, and of these he regards only 7 as being unquestionably authentic. He found no reports of syphilis of the seminal vesicles.

In all the cases reported the chief pathological evidence was enlargement, varying from a mere thickening to a tumor as large as two fists. In 4 cases the enlargement was of the right cord, and of the left in the remaining 3; in 1 case only, that of L'Honneur[75] are we given any postmortem findings. The patient had denied all syphilitic infection but the autopsy revealed that death was due to a gummatous tumor in the wall of the right auricle, while the cord of the normal right testicle appeared to be infiltrated by a fatty mass, so that the vessels of the cord were obliterated by fatty and fibrous tissue. This tumor was at first thought to be carcinoma, but the microscope quickly revealed its true nature. The course of a syphilitic involvement of the vas deferens apparently differs in no way from a similar process in the testicle.

Possibility of Luetic Infection of the Vesicles.—Although Thompson states that it has never been shown that the seminal vesicles may be involved in a general syphilitic process, he is nevertheless, of the opinion that there is no reason why these organs should be exempt from attacks by the *Spirochæta pallida*, and undoubtedly if the seminal vesicles of all syphilitics who come to autopsy were carefully examined, evidence of involvement would sometimes be found.

Non-specific Infections of Testicles and Epididymes. -The most common disease of the testicle met with in general practice is probably epididymitis, which is much more often seen than orchitis. While no age is exempt from it, it is most frequently encountered during the years of greatest sexual activity. Inflammation of the testicle may follow infection from the seminal vesicles, the urethra or the bladder, but under these conditions it will usually be noted that the epididymis is also the seat of an inflammatory process. Occasionally infection may be carried to the testicle during the course of an acute infectious disease, or a pyemia, but this is a rare occurrence except in the event of mumps, in connection with which orchitis, as we have already noted on page 43, occurs quite frequently. In infants and little boys this complication is very rare, but when the victim of parotitis has reached puberty that is, in adolescence and early manhood especially, his chance of a testicular involvement is greatly increased, becoming practically "fifty-fifty." The epididymis is not affected.

Gonorrheal Epididymitis.—Inflammation of the posterior urethra sets up a like condition in the epididymis. The usual, but by no means universally accepted explanation, is that the inflammation travels from the urethra up the ejaculatory duct and along the vas deferens, extending to the lymphatics of these structures. Unless there is inflammation in the posterior urethra, or it has suffered trauma, which seldom happens, epididymitis is never observed. Moreover, there often will be symptoms of inflammation of the vas deferens before there is any reason for attention being directed to the epididymis.

Thus, any patient who harbors a chronic posterior urethritis stands in constant danger of recurring attacks of epididymitis, for a multitude of exciting factors, violent exercise, as horseback-riding or dancing; unwise or ungentle instrumentation; alcoholic and sexual excesses, can produce urethral irritation and quickly set up an inflammatory condition in the epididymis.

The inflammatory process usually begins in the globus minor, less often in the globus major, but in either event quickly working its way through the entire epididymis. The rest of the testicle usually escapes. Infiltration of the spaces between the tubules is caused by the inflammation, so that a serous exudate, often loaded with pus cells, quickly induces great tension. This exudate is ordinarily absorbed, but occasionally diffuse abscesses will appear, or small foci of pus may gather and suppurate. In severe cases the amount of fluid will be great enough to constitute a hydrocele.

A single acute attack of gonorrheal epididymitis usually subsides in a week or two, and is often too lightly regarded by both physician and patient. Sometimes the symptoms are quite mild and complete rest, with elevation of the scrotum may be all the treatment needed to establish convalescence from the acute symptoms. More often, however, there is fever, the pain becomes increasingly severe, making walking practically impossible, and the affected organ is acutely sensitive

to pressure. Swelling is very marked, especially at the head and tail, indeed, the entire testicle as well as the cord, may become involved. If pus has been issuing from the meatus before the swelling began this will usually cease temporarily, being checked by the hypertrophy of the parts; the scrotum rapidly becomes edematous and very red and hot, the whole scrotal pouch presenting an ovoid mass, sometimes as large as both the patient's fists. If the cord is also implicated, the redness and swelling may extend to the groin.

Treatment.—Palliative measures are of the first importance in this acute inflammatory condition. Proper suspension and bandaging so as to give rest to the affected parts is absolutely essential, these measures having been already described in a previous chapter (page 207). Equally necessary is the avoidance of sexual excitement and any physical strain or other irritating factor. Instrumentation should if possible, be avoided throughout, and should under no circumstances be employed while the inflammation is acute. Chetwood suggests that if the attack is caught in the initial stage it is sometimes possible by immediate rest and the application of sharp counter-irritation over the tender area where inflammation is beginning, in the form of a strong solution of guaiacol 25 to 50 per cent in glycerine, to cause a quick subsidence of the attack. This application should be made with a camel's hair brush on the site of the swelling in sufficient amount to produce some irritation and redness, but not enough to blister. If a favorable effect is obtained the result is prompt, relief occurring within twenty-four hours.

Relief of Pain.—When epididymitis is once established, treatment must be directed toward the relief of pain and hastening the process of resolution. The extensive congestion and edema of the testicular tissue confined by the relatively inelastic tunica albuginea, gives rise to pressure likely to produce the most intense pain, for the relief of which not a few practitioners advocate extensive incision for the establishment of free drainage. Such drastic measures should not, however, be necessary except in the most severe infections. Ordinary puncture, and the withdrawal by syringe of as much blood and serum as possible, will serve every purpose.[131]

Palliative Methods.—Though many applications and ointments have been tried and recommended (guaiacol, ichthyol, belladonna and iodine in various guises) the ice-bag or diathermy, according to the individual need of the patient, are of much more value than medicinal applications. When the acute stage is somewhat passed, gentle continuous pressure, such as can be obtained by a rubber bandage, may prove serviceable.

Vaccine Therapy.—Vaccine therapy has proved useful in many cases, and may be given a trial, although some of the most eminent authorities regard it as of little value. The dosage usually recommended is 20 million bacteria for the initial administration, with ascending doses repeated every second day.

Non-specific Infections. Though less commonly than by gonorrheal infection, both epididymis and testicle may be subject to inflammation set up by other organisms, most frequently a staphylococcus, though the colon bacillus, *Bacillus lactis aërogenes*, and various streptococci from time to time are proved guilty. It is possible for such an infection to arise during the course of gonorrhea. Two types of such infections have been postulated:[68]

1. *The Pseudo-tuberculous Type.*—The inflammation begins, often in a patient with no history of antecedent urethral lesions, as a chronic inflammatory nodule in the globus minor, but slightly tender and causing no constitutional disturbance. It passes for tuberculosis until, quite spontaneously it disappears, leaving a scarcely perceptible thickening of the epididymis.

2. The inflammation begins, not in the epididymis at all, but in the seminal vesicle and vas deferens. There may be stricture, prostatism, chronic posterior urethritis, or the infection may begin independently of any known preceding lesion. At the outset the vesicle becomes not only large, but thickened, and finally of a wooden hardness and great thickness. There may be abscesses in the vesicle or in the adjacent lateral lobe of the prostate, but these are uncommon; the vesicle usually feels about the size of the little finger, and is not very sensitive.

From the vesicle the inflammation advances along the vas as a periderentitis, the whole cord becoming thick, sensitive, adherent. It usually reaches the size of a lead pencil and may be twice as large. The progress of the inflammation may sometimes be followed day by day as it advances down the vas toward the epididymis, although the opposite course is frequently seen also, the epididymis being first involved and the cord much thickened secondarily. The tendency of the infection is to result in abscess, either in the epididymis or at the external abdominal ring.

Diagnosis.—Non-specific infections are likely to offer diagnostic difficulties even to the most expert. Frequently the only way by which we can distinguish the first of the types just enumerated from a tubercular infection is to wait and see, for tuberculosis is essentially chronic, while non-specific infections will disappear spontaneously. The fact that such an infection may be coincident with that of the gonococcus increases the difficulty, for under such conditions even a positive complement-fixation test is no proof that the inflammation of the epididymis is of gonococcal origin.

Relapse is very likely to occur in any type of epididymitis. Frequently, the acute attack may gradually subside into a chronic condition, the epididymis never regaining its normal state. In the gonorrheal form a fresh infection may at once set up a new inflammation but in many men repeated new infections never reproduce the epididymal complications. But when the inflammatory condition has been originally due to some other causal organism, relapse is much more prone to occur. According to Keyes relapses are habitually milder

but more long drawn out than the first attack. The only relief for such cases is drainage of the suppurating focus and division of the vas.

Remote Effects of Epididymitis.—Inflammation of the epididymis has probably been the direct cause of death in very few, if any, of its victims. It is its ability to do permanent and irreparable damage to the sexual apparatus that constitutes its greatest menace; while it may not destroy life, it is yet able to prevent it from coming into existence. It has been stated that the only female sterility of practical importance is caused by male gonorrhea,[119] and while this is no doubt an over-statement, it contains enough truth to greatly increase the gravity already attached to a gonococcic infection. Male sterility as a sequel of gonorrheal epididymitis is at present receiving more recognition than has heretofore been accorded to it, but it is probably far more prevalent than any statistics now available would lead us to suppose.

Azoöspermia.—Bilateral gonorrheal epididymitis is very likely to be followed by complete sterility, due to occlusion of the convoluted tubules of the epididymis by the healing process following inflammation. This occlusion is most frequently observed in the globus major. When both testicles have been involved in a gonorrheal inflammation, indurated nodules may remain in the globus minor for a long time, often for months or even years, after all trace of the inflammation has disappeared. These nodules consist of fibrous tissue which has been built up within and around the epididymal canal, constricting its lumen to such an extent as to cut off communication between the testicle and the seminal vesicle.[139] The passage of spermatozoa from the epididymis to the urethra is thus completely prevented, but as the individual suffers no diminution of potency nor failure of sexual desire, he frequently remains ignorant of the fact that he is incapable of becoming a father. A more general appreciation of the possibility of sterility under these conditions on the part of the laity might serve to avoid much marital discord.[78]

Acute Orchitis.—Acute inflammation of the testicle proper can result not alone from metastasis during acute infectious disease, especially mumps, but also from bacterial toxemia.[4] Though rare, not a few cases have been reported where orchitis has appeared spontaneously in a previously healthy individual, causing not only acute local symptoms but profound constitutional disturbance as well. There may be difficulty in determining whether we have to do with an orchitis or with torsion of the testicle, the symptoms in both conditions closely simulating each other. Torsion may indeed, precede an orchitis, for the circulation of the testicle is likely to be impeded, which will set up a necrotic condition and offer a fertile soil for bacterial invasion. Sometimes the diagnosis can be established only by surgical exploration.

Orchitis is seldom fatal to the individual, but destruction of the

testicle frequently occurs. Even if it is not necessary to excise the gland, it is very likely to atrophy within a short time.

The *orchitis of mumps* is the most prevalent and serious inflammation of the testicle ordinarily in evidence. This subject, which has not received the attention which its prevalence and severity warrants, was very fully discussed four years ago by Wesselhoeft of Boston,[133] who gathered statistics from the literature bearing upon etiology, frequency and other mooted points which are instructive as well as highly interesting. A compilation of all his statistical material, mostly military and naval, gave him an incidence of 18 per cent of cases of mumps which developed orchitis, which is significant in view of the current opinion that at least one-half of the males who develop this disease after reaching puberty, suffer the complication of orchitis. Bilateral orchitis was found proportionately less frequent than bilateral parotitis.

Orchitis occasionally occurs without preliminary inflammation of the parotid glands, the entire course of the infection being confined to the testicle. Though this is decidedly uncommon, no less than 64 cases have been collected from the literature. In the majority of cases, however, the orchitis appears from three to seven days after the height of the parotitis, but it may occur at almost any time, even as late as the third week. It is frequently ushered in with a chill and a sharp rise of temperature, with headache and pronounced weakness, while these may be followed by diarrhea, nausea, vomiting, and, in rare instances, delirium. There is pain in the testicles, sometimes merely a slight discomfort and sense of weight, ranging all the way from this to excrutiating anguish radiating to the thigh, the inguinal or sacro-iliac region, or even to the abdomen. The testicle swells rapidly, often quadrupling its normal size, and will be firm and very sensitive on palpation.

Swelling and tenderness of the epididymis and spermatic cord may show that these adjacent structures are also involved in the inflammatory process, the epididymitis being frequently accompanied by the formation of hydrocele. The skin of the scrotum is often red, edematous and exceedingly sensitive to the touch. When the prostate is also involved there may be a urethral discharge, varying from an opaque to a yellowish appearance not unlike that of gonorrhea. Smears of this fluid, however, show no organisms, and it ceases in the course of forty-eight hours. If the temperature remains high for more than a day, symptoms resembling those of meningitis or encephalitis may develop. When both testicles are affected simultaneously the constitutional manifestations are much more severe, but involvement of both testicles is very rare. Two cases have been reported where orchitis affected an undescended testicle.

Atrophy of the Testicles.—Operative interference is seldom employed even in the most severe cases of the orchitis of mumps, as the immediate outcome is in no way improved by such measures. Some authorities

however, have advocated multiple incision of the tunica albuginea during the height of the infection, believing that the relief of tension would restore the circulation and prevent later atrophy of the gland, which they regard as due to the increased intra-testicular pressure caused by the inflammation.[111] To be effectual such intervention must be undertaken early, and the contagiousness of the disease somewhat increases the difficulty, one operator at least, having himself become infected.[2] But as subsequent atrophy of the testicle occurs in nearly one half of these orchitis patients, every effort to prevent such a serious sequel ought to receive thoughtful consideration.

INFECTIONS OF THE VASA DEFERENTIA.

Gonorrheal Deferentitis.—Ordinarily, in the presence of an acute gonorrheal epididymitis involvement of the vas deferens will attract little or no attention. Deferentitis can, however, occur without coincident inflammation in either epididymis or testicle proper. The focus of infection is usually in the posterior urethra or in the prostate, whence the infecting organism reaches the epididymis, either by way of the lymphatic ducts, or a retrograde peristalsis of the vas deferens, such as has been described by Loeb. While passing through this duct it is possible for the gonococci to adhere to the internal mucous coat of the vas, later penetrating the intervening muscular layer and the external areolar covering. The deferentitis which is produced presents the following typical microscopical picture:[138]

The epithelial cells of the vas become swollen and partially desquamated; round-cell infiltration of the submucosa and muscularis takes place; and acute lymphangitis of the vas deferens arises, evidenced by the polymorphonuclear infiltration of the lymph spaces of the muscularis. Such a deferentitis will usually subside in a short time without going on to abscess formation, but occasionally gonococcic inflammation of the spermatic cord has been held responsible for intra-abdominal abscess of obscure origin.

Deferentitis of Indeterminate Origin.—A small group of cases of inflammation of the vasa deferentia, the cause for which could not be determined has been occasionally described.[137] Suggested etiological factors are trauma, a preëxisting disease such as rheumatism or influenza, or a focus of infection elsewhere in the body. The symptoms in general are those of pelvic abscess, but on incision of the inguinal canal, the vas and the other component structures of the cord will be found swollen and bathed in serum; or abscess formation will have already taken place. Evacuation of the pus is usually followed by uneventful healing and bacteriological examination fails to throw any light upon the cause of the infection.

Differential Diagnosis.—The differential diagnosis in these cases may offer many difficulties. Aside from abscess of the abdominal wall, it is very likely to simulate an irreducible inguinal hernia, and if

the swelling of the cord is rather high up toward the internal inguinal ring, it may very well be mistaken for a mass in connection with an acute appendicitis. An infected neoplasm of the spermatic cord might also make differentiation difficult. The tuberculous vas deferens presents alternate swellings and normal areas giving it a beaded effect which is quite characteristic.

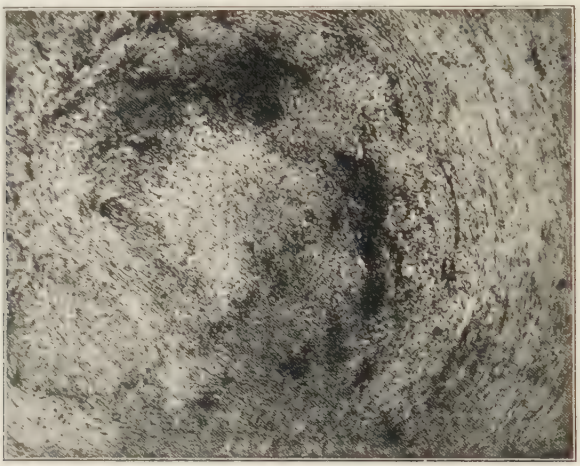

FIG. 55.—Photomicrograph of long-standing tuberculosis of the vas deferens. Almost the entire lumen of the vas is filled with tuberculous granulation tissue. There is a small slitlike aperture in the right center of the picture which represents all that is left of the lumen.

DISEASES OF THE SEMINAL VESICLES.

Tuberculosis. Many years ago, the great French urologist Guyon, asserted that in the vast majority of cases of genital tuberculosis in the male, the original focus of the disease was in the seminal vesicles. It was his belief that the extension of the process took place from within outward, progression being toward the external genitals rather than away from them. Young, after a very careful study of genital tuberculosis felt that we can justly draw the deduction that in almost all cases the primary focus in genital tuberculosis is the seminal vesicle.[141] From the vesicles (or more rarely the prostate) the epididymis or testicle is subsequently involved, the external disease attacking both sides in from one-third to one-half the cases. The seminal vesicles are not only the primary focus from which the epididymis is involved, but are also responsible for the participation of the prostate, bladder and even the kidneys. It is quite possible that the infection may travel by the posterior chain of lymphatics to the mediastinum and lungs.

Pathology. The pathology of seminal vesiculitis is similar to that of inflammation arising in other structures having a cavity lined with

mucous membrane. The acute stage begins with engorgement of the vessels, and this may progress to the stage of abscess formation. The subacute stage is distinguished by the round-cell infiltration of the wall, while the chronic stage shows an increase of hyaline and connective tissue stroma, which may greatly thicken the wall and result in reducing the lumen of the tube. This condition is invariably associated with a periseminal vesiculitis, with eventual formation of adhesions to the surrounding structures. According to Dillon and Blaisdell,[140] there are two distinct pathological changes observable in the chronic form of seminal vesiculitis: (1) Those involving the intrinsic structures; (2) the extrinsic structures. Microscopically their mildest cases showed more or less thickening of the mucous folds, the result of round-cell infiltration and the presence of granulation tissue, together with some denudation of the mucosa. Later on these folds become more fibrous in character, and recesses form between them containing inflammatory exudates, secretion, necrotic cells and microörganisms. In some areas the lumen is very greatly reduced in size. In the more advanced cases the granulation is increased and more lobules are obliterated, their places being taken by fibrous tissue. The fibrous sheath of the vesicle shows thickening and leukocytosis, and round-cell infiltration is more in evidence in the perivesicular tissues. In the later stages the destruction of glandular tissue is much more advanced. The microscopic picture shows dense perivascular tissues and vasa deferentia, and, as these are closely associated with the seminal vesicles, may give the examiner an immediate clue to the existence of disease in these organs.

Proper palpation of the vesicles is of prime importance, and the best and most effective method has been thus described:[146] The seminal vesicle is palpated through the rectal wall, immediately over that organ. The perfectly normal vesicle is soft and rather indistinct in outline, somewhat mobile and easily pushed to one side, although it cannot be permanently dislocated. It is only by becoming thoroughly familiar with the normal "feel" that one can hope to recognize pathological conditions promptly. The protected well-lubricated finger of the right hand is introduced into the rectum, palmer surface upward. When the finger tip has penetrated about 1 inch, the palmar surface should be turned downward and the finger advanced forward and sideways to the right seminal vesicle. The vesicle should be palpated from its very top down to its meeting place with the cord, the examiner being careful to keep his index finger, wrist and forearm extended in a straight line. Thus, unless the examiner has a forefinger shorter than the average, he can reach the top of the vesicle in nineteen out of twenty patients. The twentieth patient will be an obese individual with fat flaring buttocks. In such a subject the portion of the seminal vesicle which can be reached will be that nearest the prostate, that is, the lower section where it joins, or is about to join, the cord. If this

portion be found diseased it may be assumed that the remainder is in a like condition.

The examiner should note whether the vesicles are swollen and boggy, small, thickened, nodular or calcified, and whether they empty on stripping. The fluid obtained by stripping can be examined for pus and blood cells, to determine the presence of bacteria or to ascertain the state of the spermatozoa; a specimen should also be cultured for bacterial differentiation and autogenous vaccine preparation. The authors' preferred method of obtaining such a specimen is, however, to gather it through a sterile endoscopic tube, as they believe contamination from the extensive bacterial flora of the anterior urethra can be more easily avoided by following this plan.

Changes in the Colliculus.—Endoscopy will show changes of the colliculus, although these should not be regarded as pathognomonic. These changes may be roughly grouped into two types, although no hard and fast distinctions are possible. Even in old sclerotic vesicles the colliculus may be normal in form and color, but more often the surface will be very irregular and covered with knob-like excrescences, giving it a bosselated appearance. Again it will be below the normal size and very firm in consistency, its color being changed from the natural pale yellow-red, to a pearly-white tint which, when in evidence, is very characteristic. There is often an enlarged utricle with irregular borders. If the patient complains of pain at the end of urination, or of pain in the back, of cold sensations in the glans, of diminished potency, and in general, of the recognized symptoms of sexual neurasthenia, the endoscope will usually reveal a small irregular, atrophic colliculus, gray in color.

In the other type of change, the endoscopist will often see a colliculus twice or even three times its normal size, somewhat resembling a raspberry in appearance, greatly congested, and its smooth surface scattered over with red and white spots. The slightest manipulation induces bleeding. The openings of the ejaculatory ducts may not be visible at all, if the hypertrophy is very great, but more often a small area around the duct openings will show considerable congestion, by which they may be easily located. When the colliculus is of the small sclerotic type the ducts can usually be made out, the openings sometimes being wide and gaping, probably being rendered rigid by the infiltration of the walls. If but one duct is affected its fellow will generally be normal, or nearly so. Rarely, the diseased duct will exude pus, which becomes more noticeable if the vesicle is massaged. If pus is thus in evidence, it may be regarded as quite surely indicative of the existence of seminal vesiculitis.[65] Examination with the cystoscope may show a slight congestion of the area about the swollen vesicles.

Technic of Seminal Vesicle Instrumentation.—After the patient has been prepared as for any urethral instrumentation, the urethra is rendered insensitive by means of a local anesthetic and the meatus

scrutinized. Should the orifice prove too small for the passage of a 28-French endoscope, meatotomy will have to be performed, so that a posterior tube endoscope may be introduced, the verumontanum examined, and the openings of the ejaculatory ducts located. Although the position of these orifices varies considerably in different individuals, they are usually found high up on the lateral walls of the verumontanum, slightly outward from the opening of the utricle. Once these orifices are located, it requires but little skill to catheterize them with a specially devised metal catheter.

But if the colliculus be swollen and granular, the ducts may be quite invisible, and under such circumstances it may be necessary to probe gently in the region where the orifices should normally be found, until the instrument can be made to pass. Occasionally all that can be done at the first session will be to cauterize the swollen verumontanum with a chemical agent, preferably phenol (carbolic acid) 50 per cent in glycerine, then waiting until such time as examination of the ducts becomes possible.

FIG. 56.—Delzell's olivary tip ejaculatory duct catheter. This instrument has proved to be most useful in the diagnosis and treatment of seminal vesiculitis.

Delzell's Ejaculatory Duct Catheter.—When the technic just described was first undertaken no instrument entirely fitted for this purpose could be found. Working in conjunction with one of the authors, William Robert Delzell of New York, devised two new instruments, an illustration of one of which is here presented (Fig. 56). This device consists of a nickeled steel tube, 23 cm. long and of 6-French caliber, except at the catheterizing end, which is 4-French for the final 1.5 centimeter. This end is olivary in shape. A firm handle is placed on one side, and the receptacles for the fluid are placed at the opposite side at right angles to the main shaft, so that there is no interference with the operator's vision while the injection is being given.

The other instrument is merely an ordinary 4-French catheter, open only upon the end.[39]

Roentgenological Examination.—Seminal vesiculography has become an important means of diagnosis in many pathological conditions in this region. It was first suggested in 1920 by Young and Waters[144]

as an efficient method of determining the patency of the ejaculatory ducts or vasa deferentia in those cases of sterility where epididymovasotomy may be contemplated; to determine whether stricture of the ejaculatory duct, of the vas or of the outlet of the seminal vesicle is present; to disclose the condition of the ampullæ of the vasa deferentia or of the seminal vesicles in inflammatory or tuberculous conditions; and to show the state of the seminal tract in studies undertaken to determine the cause of those vague indefinite pains in the region of the prostate, of which some patients complain.

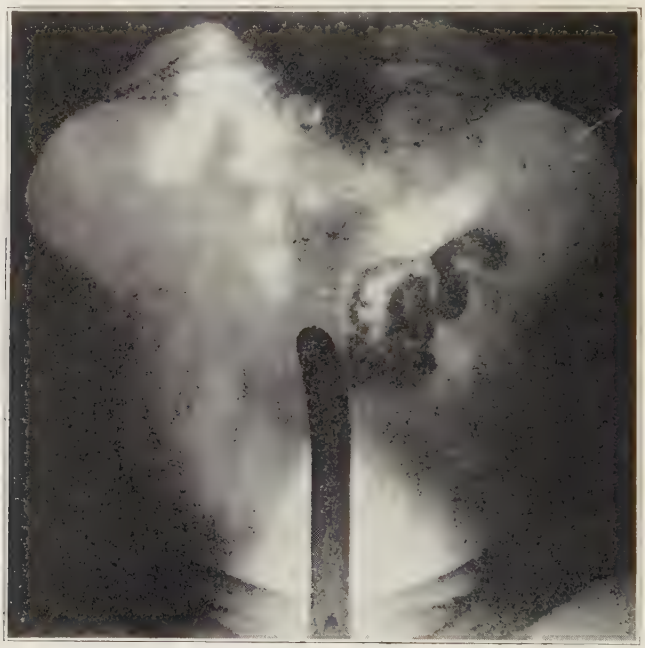

FIG. 57.—The ampulla of the vas deferens in this case is somewhat enlarged and shaggy in outline. The seminal vesicle is enlarged and its lumen is also irregular in size and ragged in outline. This vesiculogram indicates a chronic inflammatory condition.

A specially designed forked cannula was used by Young and Waters, who were thus enabled to inject both ejaculatory ducts simultaneously. As one branch of this cannula is 3 mm. longer than the other, it is easy to introduce the longer tube into one duct for a distance of about 3 mm. and then be free to catheterize the other duct with the shorter tube, after which the instrument is pushed home until arrested by the junction point of the two tubes against the anterior surface of the verumontanum.

We employ a 20 per cent solution of sodium iodide as an opaque medium, and this is injected into the ejaculatory ducts until the patient becomes aware of a sensation of fulness in the region of the

rectum. The value of these roentgenological findings needs no emphasis. Fig. 58 shows an abscess of the seminal vesicle which was verified at operation. Besides being useful in making the diagnosis of chronic abscess formation seminal vesiculography will reveal stricture of the vasa deferentia or ejaculatory ducts and other pathological or anomalous conditions of these organs which could not readily be recognized by any other means.

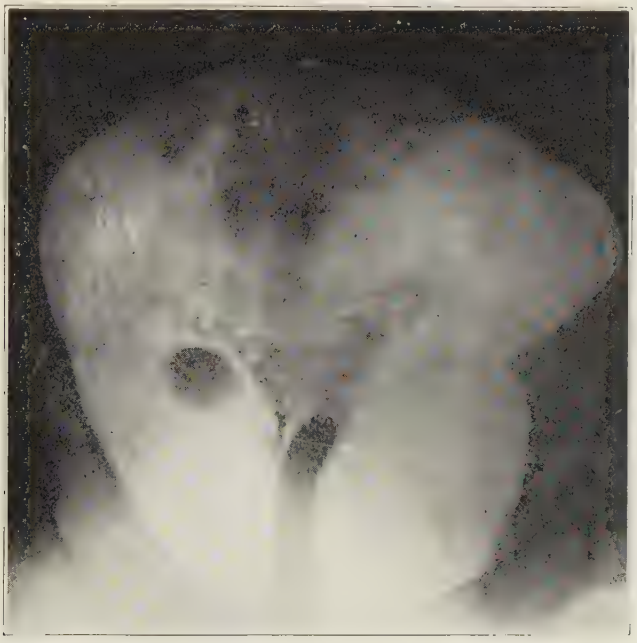

FIG. 58.—Both right and left seminal vesicles have been injected with sodium iodide through the Delzell catheter by way of the ejaculatory ducts. The right seminal vesicle shows the presence of an abscess which was verified by operation.

Treatment of Seminal Vesiculitis. — *Non-surgical treatment* consists in regulating the diet, so as to avoid alcohol in all forms, red meat, spices and other irritating foods. The patient should be given definite instructions regarding personal and sex hygiene, and suitably impressed with the importance of adhering to them. As constipation may cause congestion of all the pelvic organs, it is essential that the bowels be kept free and open. Hot rectal douches and hot sitz baths frequently prove very helpful.

Massage, when properly applied is of the greatest therapeutic value, and may be used two or three times a week. It should be vigorous, but at the same time not forceful enough to cause bleeding. The patient should not, however, be permitted to form a massage habit,[138] although if the massage be applied with sufficient vigor there should be little danger of this.

Medication. The silver salts, acriflavine, mercurochrome and potassium permanganate have all been advocated as instillations or irrigations. We believe that it is well from time to time to change the drug employed, as this does not give the invading bacteria opportunity to become tolerant of any particular one. Instrumental dilatations of the posterior urethra tend to break down the bulbous formations, to open the ducts and by improving the condition of the posterior urethra, to give better drainage to the seminal vesicles and prostate.

Medical Treatment by Vas Puncture.—The possibility of applying medication to the seminal vesicles by vasotomy was first suggested by Belfield,[9] a dozen or more years ago. Various minor changes and improvements in this procedure have been brought forward in the interval, but Belfield's original technic is still largely followed. Of the different medicaments employed for this purpose, collargol in

Fig. 59.—Specimen showing immensely enlarged seminal vesicles; *P*, prostate gland; *VD*, vas deferentia; *SV*, seminal vesicles. This type of lesion can never be cured by any kind of palliative treatment. Diagnosis is readily made by vesiculogram.

10 per cent strength has been recommended[11] as the only one sure to enter the vesicle, and to distend it to a maximum degree. One per cent sodium bicarbonate also enters well, but its only action is to improve the drainage by dissolving the vesicle secretions. Acriflavine in efficient antiseptic strength is too great a tissue irritant to be safely employed.

Lespinasse's Method.—Lespinasse's method consists in percutaneous puncture of the vas deferens and the injection of bactericidal serum. The technic which he employs is relatively simple, but it requires especially devised instruments and much manual skill. The equipment needed is: (1) A puncture clamp, an enlarged tenaculum, the teeth of which are at right angles to the side of the loop of the instrument. The teeth also run by one another a goodly distance, thus making a relatively straight rod. This instrument can be improvised with a large Hagedorn needle and two artery forceps. (2) A

"T" clamp, which is a forceps with its two blades set at right angles to the shaft of the instrument, these shafts being "belled out" so as to allow room enough for the fold of scrotal skin with its retained vas. There is also a big clamp which can only be used on a patient with a long scrotum; otherwise one cannot apply the clamp as the space between the testicles and the external ring is too short.

Technic.—The clamp is opened wide and the testicles passed through the opening. The clamp is now slowly closed, the scrotum and the contained spermatic cord being spread out as much as possible, and the vas identified, while it is being closed. When fully closed an assistant holds the clamp steady as the operator inserts a needle into the lumen of the vas, following the same technic as that employed in puncturing a vein.

To use the puncture clamp or "T" clamp, the vas is isolated in a fold of scrotal skin, and the skin worked down until that directly over the vas is tense, and the vas made prominent, so that the needle is readily inserted into its lumen. Puncture of the vas for the injection of fluids into the seminal vesicles is thus made possible without cutting the skin.

Injection through the ejaculatory ducts has proved successful in our hands. We have injected a large number of cases of chronic seminal vesiculitis with 10 per cent argyrol solution, and the patients apparently received as great relief from this procedure as that afforded by the Belfield operation, inasmuch as they have not alone the benefit of antiseptic medication, but also that afforded by the improved drainage resulting from the dilatation of the ejaculatory ducts.

INTRA-SCROTAL TUMORS.

In a recent study of intra-scrotal tumors[61] it is very aptly stated that in actual practice it is rarely possible "to make a nice differentiation of the type of tumor, or even in many cases to identify the swelling as a neoplasm." The clinician, therefore, should endeavor to find the answers to two questions: Is the swelling a tumor or not? and Is it benign or malignant? In seeking to solve the first problem the possibility of hernia simulating the form of certain tumors such as lipomas of the upper part of the cord, must be kept in mind. On the other hand, such masses as dermoids, not unlikely to be found in the inguinal canal, may suggest hernia very strongly, sometimes even being reducible and giving an impulse on coughing. A tumor may be concealed by a cyst or hydrocele, or the presence of these may lead to a mistaken diagnosis of tumor. Many times a neoplasm will so closely mimic the clinical conditions offered by tuberculosis or syphilis, that even an experienced examiner may be deceived into making a diagnosis of one of these affections.

TUMORS OF THE TESTICLE.

Malignancy of the Undescended Testis. –It is a very prevalent impression that undescended testicles are more likely to become malignant than those which lie in their normal position. Yet when Bland-Sutton in 1910 examined all the museum specimens in London, he found but 14 specimens of malignant undescended testicles. Kenneth Bulkley, three years later, made a thorough search of the literature[14] and discovered but 57 cases reported in all languages, to which he added 2 of his own. Examining hospital statistics gathered in various countries, Bulkley found that in a total of 182,729 male admissions there were 3 cases of malignant growths of intra-abdominal testicles, "about 1 in each 60,000 cases." Coley[24] personally observed 65 cases of sarcoma of the testicle, of which 52 were in the normally descended gland, and the remainder in the undescended testicle.

From these figures one can hardly fail to be impressed with the fallibility of medical superstitions and "impressions," yet in defence of them, we very recently find two English surgeons[113] stating that their findings, 4 neoplasms of undescended testes in a total of 38 cases of testicular tumor, do not substantiate the opinions of Tanner and Bulkley that the abdominally retained testis is relatively immune to malignant changes.

Furthermore they consider that theoretically there should be a relatively increased frequency of malignant disease of the imperfectly descended organ, because the testis, when in the abdomen or inguinal canal, is exposed to certain abnormal conditions which do not affect the scrotal testicle. When the gland lies in the inguinal canal it is liable to suffer repeated small injuries from the constant contractions and movements of the abdominal muscles forming the inguinal region; the abdominal testis is exposed to varying changes in intra-abdominal pressure, and is likely to be compressed when any sudden effort is made. The importance of these factors in relation to an organ already the seat of disturbed function and embryological defects can, of course, be only a matter of conjecture. The relatively increased liability of the imperfectly descended testis to undergo malignant changes may depend on the fact that the organ, influenced by its unusual surroundings, is more susceptible to the effects of minor injuries and compression.

The writers just quoted have never encountered a case where an undescended testicle, surgically placed in the scrotum, later became malignant. Such a case, however, has been reported in this country recently,[32] and the importance of a discussion of the relative liability to malignancy in the descended or undescended testicle is increased by the possibility of such an occurrence, inasmuch as it may very well influence the surgeon's judgment when he is called upon to decide as to the handling of cases of undescended testicles presented to him for

treatment. This will be further discussed when the technic of the operation is considered (page 263 *et seq.*).

Classification of Testicular Tumors.—Much has been written concerning the nature and origin of neoplasms arising in the testicle. The confusion concerning this as Southam and Linell have remarked, can best be summarized by comparing the views of three recent workers on this subject. Tanner in a series of 101 cases found all his 97 malignant growths to be carcinomatous. Bulkley considered that of 59 cases of malignant testis, 40 were sarcomatous. Ewing made the statement some years ago that all testis tumors were teratomatous in origin, and he still holds this view with certain reservations.

FIG. 60.—Teratoma of testicle showing the mixed tissue in the gross specimen. In the lower portion there is a black nodule. Above this yellow fibrous tissue, on the inner border of which are nodules of another type.

Without entering into the question of fine distinctions, it may be briefly stated that there are usually observed but two types of tumors of the testicle, namely, teratoma and mixed-cell tumor. The majority of neoplasms arising in the testicle are malignant, not more than 3 per cent being dermoids, lipomata or benign teratoma. The malignant growths are either carcinomatous or of the mixed-cell type. Medullary carcinoma develops in the interior of the gland[113] and its appearance has been thus described:

The tunica albuginea is uniformly distended by a solid homogenous tumor without cysts. The color is rose-yellow and the consistency is somewhat more firm than that of normal testicular tissue. Degenerated zones are often visible upon cut sections. These are whitish in color, soft, and have the aspect of a tubercular process. Areas of hemorrhage are frequent. But before opening the tunica vaginalis this mixed-cell type of tumor looks like an enlarged testicle. Microscopically it is seen to be made up of large round and polyhedral cells possessing voluminous nuclei and a much reduced protoplasm.

Spermatocytoma.—Thus the commonest malignant tumor of the testis arises in germinal epithelium and has been designated by a number of recent investigators[24, 110] as spermatocytoma. According to Schultz and Eisendrath, "the tumor cell is morphologically identical with the younger cells of the spermatogenic cycle, and is probably derived from the cells of the seminiferous tubules." The chief point in dwelling upon the differentiation of these growths is that heretofore, many investigators have classified practically all tumors of the testicle as sarcomata. But, as the authors just quoted have so truly said, "Even if one is unwilling to accept in its entirety Ewing's view that all testicular tumors are teratomatous in origin, it is unfortunate that his article is not more widely known, because then there would be fewer reports of sarcoma of the testicle, undoubtedly one of the rarest of tumors of this organ; and there would be less confusion and better mutual understanding when the surgeon who thinks of sarcoma as the most frequent type of tumor, receives from the pathologist a diagnosis of carcinoma or embryonal carcinoma."

Location.—Practically all tumors of the testicle are unilateral. Tanner has recently reported a case of bilateral malignancy[120] and cites several others in connection with it, but most authors claim that the condition never occurs except as secondary to tumor elsewhere.

Trauma as an Etiological Factor.—We have already mentioned the theory entertained by those who believe that undescended testicles are more subject to malignant changes than normal ones; namely, that contraction of the abdominal muscles may traumatize the ectopic testicle, more especially if it lies at, or near the internal ring. Trauma has generally been conceded to be an especially important factor in the etiology of any form of scrotal neoplasm external or internal, and mention of it is practically always made in every discussion of that subject. Actually, however, the true origin of testicular tumor, like that of tumor elsewhere in the body, is decidedly obscure, and it is likely that were we to make systematic inquiry of every male patient as to whether or not he had ever suffered trauma in the scrotal region, we would get very few negative answers. *Post hoc ergo propter hoc* holds good here in very many cases.

Differential Diagnosis.—In view of the possibility of malignancy of an undescended testicle, the first and most important point to be established is whether or not both testicles are in the scrotum. Before

the disease has become sufficiently advanced to form a palpable tumor it may be very difficult to establish the diagnosis, as the condition cannot be easily differentiated from renal colic, appendicitis or cecal tumor. When one cannot locate the testicle, either in its normal position or in the inguinal canal, he should feel a strong suspicion that he is confronted with a malignant ectopic testicle.[24]

Malignancy of the normal testicle is very difficult to recognize in its early stages. Even after enlargement is plainly visible there is a long period when pain and tenderness are entirely absent, and even when they are manifest in conjunction with hypertrophy of the gland, this combination is of little diagnostic value, since these symptoms are common to several other pathological conditions, such as tuberculosis, syphilis and others. However, in tuberculosis, as we have already seen (page 228) the progress of the process is slow, urinary symptoms are usually present, bacteriological examination will in most cases show the tubercle bacillus in the urine, and other symptoms of tubercular infection will be in evidence. In both syphilis and malignancy the testis is primarily implicated, while urinary symptoms are generally absent; progression in syphilis is slow but in malignancy it is rapid and likely to be accompanied by glandular and metastatic involvement. It is well to remember however, that the testicle may be secondarily involved in tuberculosis, and the epididymis with its neighboring structures secondarily invaded in both syphilis and malignancy.[66]

Gumma simulates tumor more often and more closely than any other condition, and it is well never to forget that generalized lues and testicular malignancy may coexist. A positive Wassermann reaction, or the application of antiluetic therapy should never be used as an excuse for too long delay. It is preferable to remove a gumma, as has been done, than to delay in the removal of a malignant tumor.[62]

On examination the cord on the affected side will usually be found much larger than its fellow because a greater blood supply is demanded by the neoplastic growth. The scrotum will contain an ovoid tumor, elastic, firm and heavy, frequently larger than an ordinary hen's egg. It does not transmit light and this should be borne in mind in connection with a possible confusion with hydrocele, which frequently accompanies malignancy of the testicle. Tanner states that a great many patients have come to him with a history of having had the scrotal sac repeatedly aspirated for hydrocele by the family physician.

The state of the cord does not help to differentiate the condition from hematocele which is another possible element of confusion. However, there are two main signs which are useful in distinguishing it, that are to be obtained by palpation of the tunica vaginalis and of the epididymis. If the tunica vaginalis can be palpated upon the surface of a scrotal tumor, that tumor is *not* a hematocele. And as the epididymis is invariably embedded within a hematocele it will be impossible to find it by palpation. Therefore, if the epididymis can

be felt between the fingers, the tumor is *not* hematocele. If information can be acquired in this way it obviates the necessity of exploratory puncture, a procedure attended by much danger should the tumor prove to be malignant.

Prognosis.—The prognosis in all types of malignancy of the testicle is exceedingly grave. The mortality is variously reckoned all the way from 40 to 80 per cent, and it is likely that these figures underestimate the real state of affairs, as many hospital patients are lost to sight after operation or other treatment, and the end-results do not find their way into available records. Operation still remains the treatment most frequently used, though radiation and the employment of Coley's toxins have received a good deal of attention during the past few years.

Relative Malignancy of Different Types of Tumors.—According to Tanner, the mixed tumor types are generally very malignant and change rapidly in structure, the carcinomatous type, although a malignant growth, being less so than the mixed type. The evolution of a carcinoma of the testicle is slow, and it remains limited for a considerable length of time. This type offers a slightly better chance of eradication, especially if the tumor is seen when it is still small and before involvement of the cord and epididymis has taken place.

Dermoids, as a rule, are benign, but the possibility of later malignant degeneration is ever-present, and it is impossible to draw a line between a relatively simple dermoid and a particularly complex mixed tumor.

Extra-testicular Tumors.—Tumors within the scrotum which do not have their origin in the testicle proper are so rare that they are seldom discussed either in text-books or periodical literature. Cystic conditions, such as hydrocele, granuloma or spermatocele of the cord and epididymis have already been mentioned, but in addition to these there occasionally occur true neoplasms of the scrotal contents which have their origin outside the testicle—in the cord, the epididymis, or still more rarely, in the tunica vaginalis or albuginea.

Tumors of the Cord.—Solid tumors of the spermatic cord are rare, for in the year 1909 Patel and Chalier,[97] in a very complete review of the literature, could collect but 89 true cases from the 120 reports which they collated. Their classification, in order of frequency was: Lipoma, 37; sarcoma and fibro-sarcoma, 22; mixed tumors, 13; fibroma, 12; myoma, 4; carcinoma, 1. It will be observed that the majority of these growths were, primarily at any rate, benign.

Lipoma.—Schiller,[108] reporting a case of lipoma of the cord some half dozen years ago, asserts that true lipoma in this region is rare, and takes its origin in the cord's tunica vaginalis, arising in the small fat lobules which this structure contains. The growth may extend upward and come to a sudden halt in the inguinal canal; or again, it may become fused with the properitoneal fat, and finally reach the testis and epididymis, or even break through the tunica vaginalis

and form a connection with the subcutaneous fat. In this last manifestation its true origin may be difficult to recognize.

These lipomas appear to arise from the subserous fat about the internal ring, and increasing in size, make their way along the canal, which is thereby much distended, often following the cord into the

FIG. 61.—Extensive carcinoma of the testis, which has ulcerated through the scrotum and is seen as a cauliflower-like mass.

scrotum. They frequently cause hernia, and if the growth is well down in the scrotum, it may be taken for a tumor of the testicle or perhaps a cyst or hydrocele.

Fibromas.—Fibromas of the cord occur much less often than do lipomas, their origin being commonly, according to Patel and Chalier,

in the caudad portion of the cord, not far from its junction with the epididymis, at a point where the various structures making up the cord are united by connective tissue. These growths are frequently mistaken for hernia, and according to Hinman and Gibson,[61] may sometimes be reduced into the abdomen, may give an impulse on coughing, or even transmit light.

Malignant Tumors of the Cord.—The malignant growths of the cord are chiefly sarcomata, being next to lipomata the most common neoplasms found in this region. The single case of carcinoma mentioned in Patel and Chalier's list, that of Tédénat and Vieu reported in 1908, appears to be the only one on record. To the 22 cases of cord tumors gathered by the French authors, Hinman and Gibson added 9, and expressed the opinion that neoplasms arise in the cord more often than these scattered reports would lead us to infer. Sarcoma of the cord is practically always found in the scrotum, very rarely in the inguinal canal. Sometimes if the growth is presumably funicular or perifunicular in origin, it can be cleanly enucleated, leaving an intact cord, but more often, if it takes its origin from the elements of the cord, it will be found impossible to free these component structures from the mass.

Prognosis of Sarcoma of the Cord.—According to Hinman and Gibson, who made an exhaustive study of the scant literature on the subject, the clinical course of sarcomata of the cord and the results of treatment are very similar to those generally reported from the handling of teratoma of the testicle. These authors therefore advise that they should receive the same radical treatment accorded testicular tumors. The lymphatics of the testicle drain directly into the retroperitoneal lumbar lymph nodes along the aorta and vena cava. The same holds true for the epididymis, spermatic cord and testicular tunics. The inguinal glands are involved secondarily to involvement of the skin, a very rare complication.

TUMORS OF THE EPIDIDYMIS.

Benign growths in the epididymis are practically unknown, and carcinoma seems to be exceedingly rare, sarcoma being the malignant growth most frequently encountered, although if we are to accept the recently well-substantiated views of Schultz and Eisendrath[109] in regard to tumor of the testicle, it is likely that many growths of the epididymis have been designated as sarcomata when they were actually tumors of other types.

Prognosis and Course.—When sarcoma arises in the epididymis its clinical course and the probable outcome are much the same as in the testicle. The growth may be very slow at first, but suddenly, often after the occurrence of trauma, according to the patient's statement, the tumor will increase rapidly in size. Extirpation of the epididymis

is all-too-frequently followed by rapid recurrence and metastasis to neighboring structures.

Tumors of the Vaginal and Albugineal Tunics.—These tumors are extremely rare. Hinman and Gibson were able to find but 4 authentic cases of fibroma of the tunica albuginea, and none of sarcoma. Apparently but 1 case of fibroma of the tunica vaginalis, that of Balloch reported in 1904, have ever been put on record in this country, and the authors just referred to could collect but a dozen reports of sarcoma arising in this structure. The prognosis and clinical course of neoplastic growths in the tissues enveloping the testicles and their adnexa is the same as that observed in growths which have their origin in the testicle, the epididymis or the structures making up the spermatic cord.

TUMORS OF THE SEMINAL VESICLES.

Neoplasms of the seminal vesicles seem to be of very rare occurrence. The earliest record of such a neoplasm which we have been able to find is the carcinoma presented before the *Societé anatomique de Paris* in 1871, by Paul Berger.[11] The description however, does not make it perfectly clear whether the growth was primary to the prostate, the vas deferens, or the seminal vesicle on the left, as all three of these structures are mentioned as involved in the carcinomatous process. Zahn in 1885,[145] reported a primary sarcoma of the seminal vesicle with metastases to the heart and other organs, and in 1886, E. Hurry Fenwick[46] showed the Pathological Society of London a specimen taken from the body of a man, aged fifty-nine years, at autopsy upon whom "the left vesicula seminalis and the adjoining posterior part of the left prostatic lobe were found hard and transformed into carcinomatous growth." Here too, there may be a question raised as to the primary location of the neoplasm.

Teubert[122] in an inaugural dissertation delivered in 1903, mentioned 3 cases of carcinomata of the vesicles gathered from the literature, to which he added a fourth, and Ceelen[17] twelve years ago published a very complete account of a fibromyoma observed in a man, aged sixty-seven years. Zahn's case of sarcoma is the only neoplasm of the seminal vesicle mentioned by Ewing in his 1922 edition of *Neoplastic Diseases,* and it is the only sarcoma cited by Voelcker[129] in his elaborate monograph on the surgery of the seminal vesicles. Voelcker however, gives a report of a benign myoma which he removed from the left vesicle of a fifty-six year old schoolmaster, and a similar growth was found by Lucksch in 1903.[77] Voelcker also found in the literature 3 cases of primary carcinoma of the seminal vesicles (Guelliot, Walter and Courvaisier) which we have been unable to verify, and may very likely be the same cases as those mentioned by Teubert.

Apparently then, so far as our examination of the literature has gone, but 1 benign neoplasm has been reported, with 7 malignant

growths, 1 sarcoma, and possibly 6 carcinomata. We have found none reported in American literature.

Johnson's Case.—One tumor of the seminal vesicle has come under our personal observation. This was a case of Dr. Harold Johnson, seen at the Department of Urology, New York Hospital. A growth as large as a lime occupied the right seminal vesicle and the bladder on the same side was covered by a bullous edema. Biopsy proved the growth to be a carcinoma, and at autopsy it was shown to be primary to the seminal vesicle.

SURGERY OF THE SCROTAL CONTENTS.

Operations Upon the Testicles.—Orchidectomy. Castration is, with the recent advances in the employment of local anesthesia, becoming practically relegated to the position of a minor operation, capable of being performed at the office. This attitude cannot be too strongly condemned, for though general anesthesia may not always be necessary, the procedure should receive exactly the same care and attention to detail that would be accorded to interventions upon less accessible organs, and should, it goes without saying, never be undertaken except after the most profound consideration of its necessity.

The testicle with its cord is delivered through an incision beginning at the pubic spine and running longitudinally downward about 8 cm. The vas deferens is isolated from the cord, ligated close to the external abdominal ring and divided. The remainder of the cord is separately divided between two ligations. It is preferable to secure each of the vessels of the stump with a separate ligature, though some surgeons content themselves by doubly tying the entire cord. The stump of the vas deferens should be cauterized.

Removal of Tumors.—The following technic is that recommended by Hinman, whose experience in this branch of urologic surgery is probably second to none, at least in our own country.[60] The operation is usually performed in two stages, inguinal and abdominal. Ordinary castration constitutes the first stage, and the extirpated testicle should be most minutely examined after removal to eliminate all possibility of confusion with syphilitic orchitis. For the second stage of the procedure the patient is placed in "a bent dorso-lateral position," that is, turned partly on his back and resting upon a pad beneath the costal margin, with his shoulder and hip upon the table. The spine is thus raised to conform to the line of incision which extends from the upper end of the previously-made inguinal cut, parallel to Poupart's ligament, in an upward curve in the axillary line at about 4 cm. below the anterior-superior spine of the ilium, terminating at the costal margin. In fat, thick-bellied men, the upper end of the incision may be extended along the rib margin, either anteriorly (Gregoire, Fredet) or posteriorly (Cuneo).

The muscle fibers and fascia are divided in a line with the skin incision

down to the peritoneum and the peritoneum should be carefully stripped back until the psoas muscle and the lower pole of the kidney are exposed. The operator may begin at the renal pedicle and work downward, or starting below at the inguinal ring, may strip the cord and vessels upward toward the lumbar region. In our own work we have followed the first method. In any case the integrity of the inferior mesenteric artery must be rigidly preserved while working upon the anterior surface of the aorta. As metastases often occur at the point where the ureter crosses the iliac vessels, and the ureter and spermatic vessels often adhere to the peritoneum when it is stripped up to the iliac fossa, it is especially necessary to clear this region thoroughly, and the dissection should also be carried up so as to include the area surrounding the bifurcation of the aorta. The vas deferens is readily located and divided where it leaves the internal ring.

More difficulty will be experienced when the operation is done upon the right side, because of the presence of the vena cava in the area to be cleared. As so large a section of the lymphatic system has been removed, the necessity of good and sufficient drainage must be especially emphasized.

Mortality Following Extirpation of Malignant Testicle.—Some interesting figures regarding the mortality subsequent to removal of malignant testicle have recently been published.[104] Of the earlier reports cited, Kober, 1899, collected 114 cases in which 10 patients, or 8.17 per cent, were well at the end of four years. In Chevassu's *Thèse de Paris*, published in 1906, 100 orchidectomies for malignancy are listed, and but 19 patients were alive at the end of four years. Of Bulkley's series already mentioned,[14] following 59 orchidectomies he knew of but 3 patients who were well after two years. Codman and Sheldon in 1914, reported 41 per cent of surgical cures, nine years being the average length of life after operation. Of Coley's 64 cases, where orchidectomy was followed by a prolonged toxin treatment,[24] something over 15 per cent were in good health after three years had passed.

At the Mayo Clinic 52 patients had undergone orchidectomy for malignancy up to the year 1922. Of this number the postoperative history was learned in 43 cases. "The mortality due to recurrence or metastasis in this series was 32.55 per cent in an average of eight and thirty-five hundredths months following orchidectomy for malignant testicle. There were operative cures in 46.51 per cent of the patients in this series, covering an average of four and a half years since operation." The observations at this clinic also showed that the abdomen is the commonest site of metastasis in tumors of the testicle, with less frequent involvement of the chest, cervical glands and general lymphatic system.

Testicle Transplantation.—None of the recently published textbooks of urology devote any space to a consideration of testicle transplantation. This operation has been so exploited in the lay press,

and undergone so much discussion by those ignorant not only of the technic and limitations of this particular procedure, but also of general surgery and even of normal physiology, that serious students and investigators have refused to consider the subject as coming within the scope of a treatise on urological surgery. The present authors feel, however, that enough scientific attention has been given to testicular grafting or transplantation, and sufficient interest is now felt in the subject by the medical profession at large, to warrant giving it space in a discussion of surgery of the testicle.

Lespinasse's Work.—The first intervention of this kind to be undertaken in the United States was apparently that of Lespinasse,[74] who reported to the Genito-urinary Disease Section of the American Medical Association in 1913 that he had successfully transplanted a testicle from a normal man to one who had become wholly impotent through the loss of both testicles. The recipient was aged thirty-eight years. The operation is thus described:

The two patients were anesthetized at the same time and the recipient made ready as follows: The scrotum was opened high up and a bed prepared in the same way as for the reception of an undescended testicle. Hemostasis was carried out with great care. Another incision was made over the rectus abdominalis muscle and carried down through the skin and fascia. The fibers of the rectus muscle were exposed and these fibers separated by opening an artery forceps plunged into the muscle. After hemostasis had been carried out, the testicle to be transplanted was removed. It was immediately stripped of the epididymis, cord and tunica vaginalis, and sliced transversely to its long axis, the slices being approximately 1 mm. in thickness. The central slice and the one next to it were taken out and placed among the fibers of the rectus muscle. Another slice was placed in the scrotum. The wounds were closed without drainage and healed by first intention throughout. Within four days the recipient of the transplantation regained his sexual powers entirely, both as to desire and ability to perform, and had retained these powers for more than two years at the time when the case was reported.

The following year the same operator published an account of a second transplantation done upon an individual who was unable to have an erection although both testicles were present in the scrotum, the glands being however "a trifle small and much softer than usual." In this instance, the testicle was removed from the donor, cut into thin slices and imbedded in the rectus muscle, while a portion of the foreign testicle, about one-third, was placed in the scrotum upon one of the recipient's own testicles. Erection took place on the third day thereafter, and continued during the two months which elapsed between the operation and the time the report was made.

Four years later, in 1918, Lespinasse advocated "hemotransplantation of the testicle" for the relief of impotency, which he defined as "acquired absence or deficiency in the secretions of the Leydig cells."

The technic he recommends is "transplantation by morcellation" which he describes as follows:

An incision is made through the skin and fat down to the rectus muscle, the fibers of this muscle are separated by means of an artery forceps, and the space then examined to make sure that no hemorrhage has taken place. This constitutes the bed into which the pieces of testicle will be carried. A semilunar incision is now made on the opposite side of the midline, and a bed prepared in the same way in the rectus muscle. The testicle to be transplanted is now cut into slices about 1 to 2 mm. thick, denuding them of the tunica albuginea. These slices are placed in the bed previously prepared in the rectus muscle, the sheath of the muscle is sewed with catgut, the skin sutured with silkworm gut, and a collodion dressing applied.

Such grafting operations may show beneficial results in a very short time; on the other hand, the transplants may be completely absorbed in the course of a few months with "coincident effacement of any benefits which may have accrued to the patient." Parenthetically, it may be remarked that the literature relating to failures is surprisingly meager. Lespinasse states that the Leydig's cells of the testicle are much more virile than the spermatogenic elements, and in experimental amounts retain their staining properties for days after definite necrosis of the tubule cells of transplanted testicles has occurred.

Contributions of Lydston.—About the same time that Lespinasse first undertook this work, G. Frank Lydston,[80] also of Chicago, attempted transplantation of the testicles from the dead to the living human body, performing the first operation upon himself, by placing a whole testis, separated from the epididymis and decorticated to the extent of about one-half its surface, in a pocket made in the fascia directly above the cord. Eight days after operation, believing the experiment to be a failure, an attempt was made to remove the transplanted gland, but only a portion of it came away, while "well-formed and abundant vascular adhesions" gave evidence that implantation had taken place. The portion of testicle remaining in its artificial bed gradually decreased in size, but there was no evidence of necrosis, and Lydston was convinced that "the implanted mass was for many months composed of living, functionating testicular tissue." This operator actively continued his experiments in testicular transplantation for a number of years. By the year 1921, he had reported upwards of twenty cases. While the technic was somewhat varied to meet individual needs, in general it may be described about as follows:

Lydston's Technic.—The testicle to be transplanted is secured from a healthy subject who has lost his life through accident, and placed in sterile salt solution or refrigerated, as soon as possible after death. Most of the implantations took place when the donor had been dead about thirty-five hours. Originally, Lydston believed that it was better to remove the epididymis, but in his later work he preserved it, and came to the conclusion that it was better to do so. The *tunica*

propria was either left intact or decorticated upon two to four narrow longitudinal surfaces, about 2 or 3 mm. in breadth, running the entire length of the gland. "These narrow bands of decortication are an extra, but probably unnecessary, provision for nutrition by the tissue juices of the implantation bed during the formation of vascular adhesions and new blood supply. Vascular adhesions naturally may be expected to form at the points of decortication. The limited area of decortication will not subsequently permit of an invasion of connective tissue from the surrounding structures sufficient to endanger the delicate glandular elements of the implanted organ. The portion of the tunica albuginea still remaining affords ample protection for the gland tissues beneath it, and probably soon regenerates and covers such portions of the decorticated area as are not occupied by new blood-vessels."

The site of implantation is preferably in the neighborhood of the testis and spermatic cord. "The tunica vaginalis will invest the implanted gland on one side, and thereby give it in part a natural covering. Where only a portion of the gland has been implanted, the cut edges of the tunica albuginea should be sutured together to protect the delicate gland tissue from connective-tissue invasion." If the alien testicle is placed in the cavity of the tunica vaginalis, the resulting mechanical irritation, combined with trauma of the sac might produce so much exudation and swelling as to cause severe pain and even endanger the recipient's own testicle.

The second best implantation site is the pelvic peritoneal space, and a third choice would be the mons veneris, the pubis being shaved and the incision made transversely just below the upper margin of the pubic hair. Lydston several times transplanted testicles into females believing that the procedure might have an ameliorating influence upon disordered mental states. His evidence however, is scanty and inconclusive. In discussing the operation as applied to males he lays particular emphasis upon the psychic influence of a testis that can be seen and felt. The psychic benefit of a consciousness of a demonstrable testis, especially in the scrotum, must not be forgotten.

Results of Lydston's Work.—In all the cases reported the implanted glands decreased steadily in size, but the operator claimed that the beneficial effects of the implantation did not diminish as the dimensions of the implant grew less. In one double implantation where both the subject's own testicles had been completely destroyed, implantation was made in the normal site in the scrotal sac, the entire glands being used, with the epididymes intact. The patient was in excellent general health and sexually active seven months after operation, "the implanted testes had atrophied only moderately, and were of relatively fair size and fairly normal consistency," and it was reported by Dr. W. T. Belfield who examined the patient at this time, that "the testes while small, are as well developed and apparently normal as in many perfectly virile men who come under our observation." A year after

implantation the general condition remained excellent and the testes, though smaller, were still well defined and of firm consistency.

Morris's Case.—In a case reported in 1914,[91] the patient was aged forty-nine years, and had lost both testicles in an accident on horseback ten years before. The donor was a man, aged fifty-six years, with a very large hernia necessitating the removal of his testicle. A wedge of tissue taken from the herniated testicle was "cut into four slices with a sharp razor, these slices averaging about 3 mm. in thickness, and in length approximately that of the testicle from which they had been removed. One of these segments was engrafted in the right scrotum, another one was placed beneath the fascial sheath of the right rectus abdominalis, and the third segment placed beneath the sheath of the left rectus abdominalis. A Weir's celluloid testicle was placed in the left side of the scrotum for the purpose of giving to the sympathetic nerves the impression of a natural mass in that vicinity. The wounds healed by primary union, and in forty-eight hours from the time that the grafting was done, the patient stated that he was distinctly conscious of the effect of the internal secretion which he was absorbing from the grafts. In fact, at that time occurred the first distention of the corpora cavernosa and corpus spongiosum that had occurred in two years."

Syringe Method of Stanley.—Much work in testicular implantation has been done by Stanley[116] of the San Quentin prison in California, with his co-workers, who were actuated, according to Stanley's own statement, by the reports of Lydston's experiments. At first using Lydston's technic, these investigators later grafted the implanted tissue directly upon the recipient's own testicle. The material used was animal testicular substance, obtained from goats, rams, boars and deer. "In order to obviate operation in which the rectus fascia of the abdomen was exposed and an implant inserted," in making the thousand implantations which he reported in 1922, Stanley used a "syringe method." "The testicular substance was cut into strips with a knife or cork borer, in sizes suitable for the filling of the pressure syringe" by means of which "the semi-solid testicular substance was injected by force under the skin of the abdomen. With this method there were comparatively few sloughs, and the patient was not subjected to a week's hospital inconvenience." Stanley claims that "in general testicular substance seems to have a beneficial effect in relieving pain of obscure origin and promotion of bodily well-being."

McKenna's Case.—In 1920 McKenna[83] reported a single case where a testicle obtained during a hernia operation was grafted into the scrotum of a man, aged twenty-six years, who had lost both testicles because of tuberculosis. The foreign testicle was "split in half, one-half being put on the right side of the scrotum after a scarification had been carefully done. The greatest possible care was given to the asepsis during the entire operation. The vas, cord, and ilioinguinal nerves were easily exposed. A suture was placed through the

cord to the freshly implanted testicle. On the left side the remaining portion of the testicle was introduced, but on this side slices of the graft were placed on various portions of the scarified tunica vaginalis. The cord and ilio-inguinal nerves could be easily brought down in proper relation to the newly-implanted testicle."

Following this operation the patient regained his sexual potency, and lost many of the eunuchoid characteristics which had become increasingly manifest after castration. These beneficial effects were still in evidence when the case was reported eight months later.

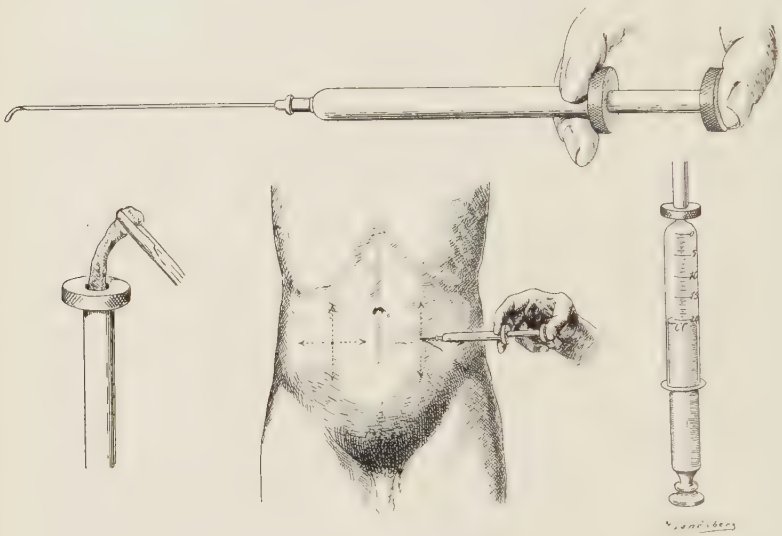

FIG. 62.—Transplantation of ram's testicle by Stanley syringe method. At the left the small strips of testicular tissue are shown being placed in the metal barrel of the syringe. Above can be seen the small string-like mass of testicular substance being ejected from the needle. In the middle the site of injections on the anterior abdominal wall is shown. Care must be taken not to inject too great an amount of material in one place as it may not be absorbed readily.

Voronoff.—The chief worker in the field of animal experimentation has been Serge Voronoff of Paris, whose work has been the subject of wide publicity and a vast amount of misrepresentation. His publication in 1919, of the results of his homo- and hetero-grafts in animals, with a careful account of the histological findings, would seem to offer quite conclusive evidence that it is possible to transplant testicular tissue from young to old animals, and that renewal of physical and sexual vigor followed in the animal recipient of the graft.

In October, 1922, Voronoff reported 7 cases in which he had ingrafted the testicle of an anthropoid ape upon a human subject. In the first 2 the grafts failed to "take," although the operator claimed that 1 patient was obliged to resume shaving, which he had not needed since

his castration because of tuberculosis, nineteen years before. In the third case the grafts were absorbed very quickly, but the patient's general health greatly improved, although his impotence was in no way relieved. In another subject both physical condition and sexual power improved. In one case only, the seventh, was there conspicuous success, and it appears to be actually upon this single case that Voronoff rests his claims to have having discovered a cure for old age.

It is evident from what has been cited above that there are but very few cases of human testicular transplantation on record which have been followed by any durable success.[126] In this country at least, the whole procedure is still very much "on trial," but within its greatly restricted limits, both as to indications and the possibility of securing suitable material for grafting purposes, the operation seems to offer great promise of usefulness, and certainly deserves the consideration of every thoughtful urologist.

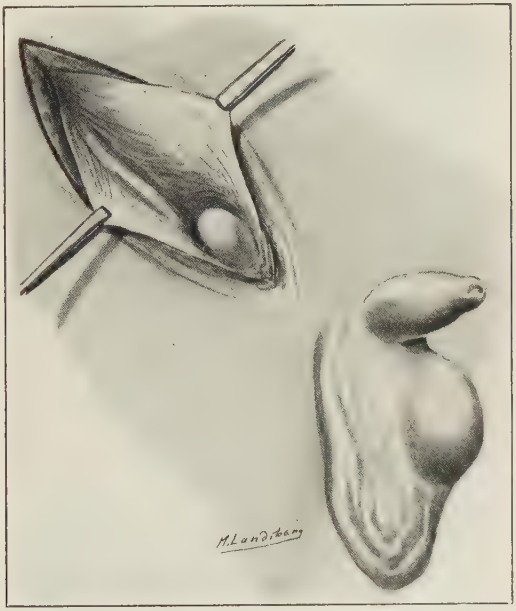

FIG. 63.—The undescended testicle is shown just outside the external inguinal ring on the right side. The empty scrotal sac is noted on the right side.

Operative Treatment of Undescended Testicle.—Indications for Operation.—Practically all individuals in whom one or both testicles have failed to descend have an accompanying hernia; or if the hernia is not actually present, the conditions are such as to make its occurrence in the future highly probable. This alone is a very good reason for undertaking an operation to place the testicle in its normal position. It is generally conceded that in its anomalous location, this gland is

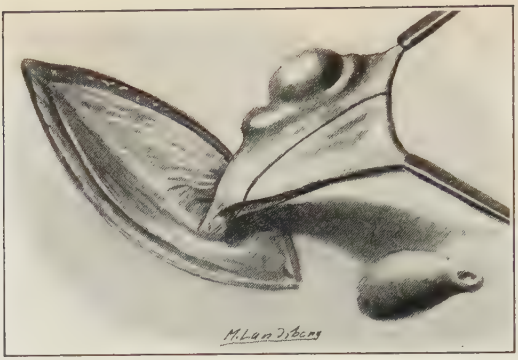

FIG. 64.—The testicle is separated from hydrocele or hernial sac if either exists, and the excess tissue cut away.

FIG. 65.—If the cord is sufficiently long the raw surfaces are closed over by approximating the cut edges with a continuous suture of catgut.

FIG. 66.—Ordinarily it will be necessary to dissect away most of the fascia of the cord. It is usually found that the vas is quite long enough. The fascia surrounding the veins usually is the cause of the nondescent. Great care is taken to separate the fascia from the veins. The former, being rigid, is all cut away, the latter, being elastic, are preserved.

more subject to trauma, and more likely to become malignant than when it is in its proper position in the scrotum. Torsion of the cord also occurs more frequently in undescended testicles than in those

FIG. 67.—A catgut ligature is placed in the fascia in the region of the globus minor. This is then brought through the scrotum in which a new bed has been prepared for the testicle. It is carried through the skin at the lowermost part of the sac.

FIG. 68.—The testicle is then drawn down into the scrotum and anchored there by tying the catgut ligature around a piece of gauze. This is removed at the end of three days, by which time the testicle has become adherent to the tissues of the scrotum.

normally placed, and as Moschcowitz[93] has pointed out, extension of a gonorrhea to a scrotal testis or metastatic involvement in mumps is sufficiently distressing, but these conditions in an undescended testis are very grave and may even menace the patient's life.

Age at Which to Operate. While there is a general concurrence among authorities that the attempt to reduce the testicle should be made during childhood, there is a wide divergence of opinion regarding the age at which the operation can be carried out with the greatest safety and assurrance of success. Keyes[68] states that "this operation should never be performed on children younger than eight or nine years of

FIG. 69.—This picture shows an undescended testicle after operation in which the testicle was not anchored to the bottom of the scrotum. The night after operation a coughing spell caused the cord to contract and the testicle was displaced to a point just under the pubic spine. Subsequent operation with the gland anchored in the manner here described resulted in perfect reduction.

age;" he also quotes Coley to the effect that "the operation should not be attempted before the eighth year or delayed beyond the twelfth." Chetwood[19] merely says "Operation should be undertaken in early youth." According to Mixter[89] "the best time is between the ages of five and twelve years;" while Eccles[43] declares "the best age at which to operate is about six to eight years."

Bevan's Operation.—The operation most commonly performed with a view of correcting the anomaly of non-descent of the testicle is founded upon the procedure advocated by Bevan in 1898.

Through an oblique incision over the inguinal canal a split is made in the aponeurosis of the external oblique muscle, extending from the external to beyond the internal ring. Whatever remains of the gubernaculum, usually found at the lower edge of the sac surrounding the retained testicle, is dissected free from its scrotal attachment. To this a hemostat is now applied, which permits the operator to exert traction upon the cord without fear of damage to the testicle itself. The bed into which the gland is to be received is made ready by breaking up with the finger any adhesions existing in the scrotum. By dividing the cremaster, the sac containing the testicle is opened as high as possible toward the external ring, great care being exercised in separating the sac from the cord, for injury to the spermatic vessels is almost sure to result in subsequent atrophy of the gland, especially in operations performed upon a young subject. The sac should be incised and the ligature placed high up, while the fibrous sheath of the cord, together with the cremaster, are completely extirpated. The lower portion of the sac is made to serve as a tunica for the testicle in its new location, the sac being retained in place by means of a purse-string suture. While the testicle is uncovered the greatest care must be exercised to avoid all trauma.

The operator now pushes his finger behind the peritoneum, thus dilating the internal ring. This will separate the vas deferens from the vessels, bringing it down over the edge of the fascia transversalis, while at the same time the bloodvessels will continue upward and inward. The fascia is split longitudinally from the internal ring as far as the deep epigastric artery, the purpose being to relax the vas so that it may be long enough to reach all the way to the scrotum, and also further extend the field for dissection. Some operators advocate division of the deeper epigastric vessels, or passing the testicle and cord behind them, but in the opinion of Mixter,[89] whose experience with this operation is very extended, this does not give any appreciable additional length to the cord, as the only structure to benefit by this maneuver is the vas, with which there is rarely any difficulty.

The peritoneum being retracted beneath the upper edge of the internal ring, it is dissected away from the posterior abdominal wall, and with the aid of the hemostat previously placed upon the remains of the gubernaculum, the adhesions between the abdominal parietes and the outer side of the bloodvessels are cut away. Mixter recommends that when the cord is sufficiently lengthened to permit the testicle to take its place in the scrotum without undue tension, an unknotted temporary suture be taken through the gubernaculum, and both ends passed out through the scrotum and clamped to the operating sheet under tension, care being exercised not to produce torsion of the cord when the testicle is drawn down. The scrotal

wound is then sutured around the vas, and the operation completed as in the routine procedure for the cure of hernia.

Fowler's Operation.—When the internal ring is lax, intra-abdominal transplantation of the cord may be accomplished as follows:[47] The inguinal canal is exposed as in the Bassini operation, the cord is ligated and cut away. The palmar surface of the index finger is now carried to the internal ring to determine the point where the deep epigastric vessels pass over the floor of the canal. When these vessels have been recognized, the finger acts as a guide by which an incision is made in the posterior wall of the canal, this incision extending from the internal ring to a point well below the level of the pubic bone. When the cord has been dissected free, its distal end is drawn out at the lower angle of the incision, while the remainder of the cord is dropped back into the abdominal cavity. The incision in the posterior wall of the canal is drawn together by through-and-through sutures. An opening is left at the lower angle which forms the new internal ring and is placed sufficiently low to compel the cord to curve upward in order to cross the pubic bone. This strengthens an otherwise weak point by forming a bony buttress anteriorly.

Other Modifications.—Three different ways are mentioned by Moschcowitz as possible of employment in dealing with the sac: (1) It may be cut off close to its attachment to the testis; (2) it may be cut off at some distance from the testis and a new tunica vaginalis formed, or (3) it may be everted and sutured. However the sac is isolated, great care should be taken not to in any way traumatize the vas deferens while freeing it from the sac, for should the small artery of the vas be injured or thrombosed there is grave danger of necrosis of the testicle.

Transplantation of the cord is possible only in those cases where the testicle is but a short distance from its normal position, in some instances freeing the vessels of all extrinsic fascial structures, teasing and occasional snips with the scissors will enable the testicle to be brought down.

Results.—To be considered successful and satisfactory the outcome of the procedure just considered should be a viable testicle permanently retained in the scrotum. Atrophy is the unfortunate sequel most to be feared. Frequently the ectopic testis will be found more or less atrophic in its original anomalous position, but numerous instances are on record where its condition has improved after it has been placed in the scrotum. It is doubtful if such surgically-placed glands are capable of spermatogenesis, but even if only their endocrine function continues, the wisdom of the intervention is fully demonstrated.

OPERATIONS UPON THE EPIDIDYMIS.

Epididymotomy.—Epididymotomy is described by Cunningham and Cook[35] as "a rational procedure for active acute, and recurrent acute and subacute epididymitis, being the application of the general surgical

principles of drainage to an inflamed structure, with the same beneficial results as in other structures." They add that "the immediate effect of the operation is a rapid relief of pain, and the high temperature and leukocytosis drop rapidly to normal, and the individual is able to return to his duties about five times as soon following the operation, as when treated by non-operative methods."

Indications for Operation.—Indications for operation may be summed up as: (1) Failure of local treatment (see page 292); (2) abscess demonstrable by fluctuation; (3) persistent and increasing pain, despite local measures for its relief, increased swelling of the parts, and high leukocyte count; (4) in chronic cases, the presence of an indurated, thickened and tender epididymis.[72] In military surgery the operation has been warmly advocated because it shortens the disability period, gives complete relief from pain and toxemia, reduces to a minimum the destruction of healthy tissue and limits the spread of the infection. No recurrences follow the operation which is simple and quickly performed, usually taking about five minutes after the patient is anesthetized.[1]

Hagner's Technic.—The procedure most commonly employed for the relief of epididymitis is that put forward by Hagner[56] in 1906. He advised the use of a general anesthetic, as the manipulations necessary for local anesthesia cannot well be carried out in the presence of such exquisite pain as is commonly found in this acute condition. This objection cannot be lodged against modern methods of local anesthesia. The incision which is from 6 to 10 cm. in length, is made over the juncture of the swollen epididymis with its testicle, and is carried downward until the tunica vaginalis is opened and all the fluid evacuated, so that the inflamed epididymis can be inspected. The testicle and cord are delivered through the wound and protected by warm sterile towels. Multiple punctures are then made into the fibrous covering of the epididymis, special attention being given to those areas where hypertrophied and thickened tissue is most in evidence. It is important to thrust the incising instrument down deeply enough to enter the infiltrated connective tissue beneath the thickened capsule. The increased ease with which the knife passes makes it easy to appreciate when the capsule has been penetrated. Hagner recommends that if pus be seen to escape from any of the punctures the opening should be enlarged and a small probe be inserted in the direction from which the pus is flowing. He believes this entails less danger of injury to the tubules of the epididymis than cutting with a knife. Judicious massage in the indicated location of the abscess will serve to evacuate the pus after the probe has been passed, following which the cavity should be thoroughly irrigated with a suitable antiseptic solution such as acriflavine or mercurochrome, and following the restoration of the testicle to its normal position, the tunica vaginalis should also be thoroughly irrigated, and then closed with a catgut suture, a cigarette drain being left in position over the incision. The skin is closed in the usual manner

employed for scrotal suture, the drain being left to emerge at the lower angle of the wound.

Allen's Technic.—Allen's technic is somewhat less complicated than that just described, but equally satisfactory results are claimed for it.[1] Under general anesthesia a small incision is made in the scrotal wall, posteriorly just above the globus major, Grasping the testicle in the left hand to render it immovable, the globus major, the globus minor and the body of the epididymis are opened by puncturing them with a sharp-pointed hemostat held in the right hand. The hemostat is pushed in to a depth of a little less than 1 cm. and its jaws then opened, permitting the escape of pus and serous exudate and at the same time

FIG. 70.—The vas deferens is first separated, ligated and divided. The diseased epididymis is then separated from the testicle, care being taken to identify and avoid injuring the vessels as they enter the testicle at its middle point. It is well to separate the globus minor and globus major before freeing the body of the epididymis, as in this way one is less liable to injure the testicular bloodvessels.

relieving tension and establishing drainage. This thorough drainage of all the affected area is most important. If a hydrocele is present, its contained fluid will be evacuated at the same time. No ligation will be necessary if the severing of any of the small arteries can be avoided. Upon withdrawal of the hemostat, the wound is covered with gauze and the testicles placed in an adhesive plaster sling stretched between the thighs.

Epididymectomy. Epididymectomy is usually performed according to the technic employed by Cabot[16] in his operative treatment of genital tuberculosis. Most operators employ general anesthesia, but as many of the patients upon whom this procedure must be carried out are

poor operative risks and frequently suffer from pulmonary complications, regional anesthesia can be used with greater safety. An incision about 2 inches in length is made over the most prominent section of

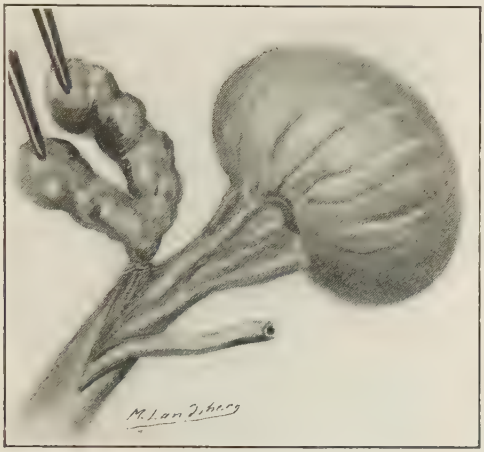

FIG. 71.—The epididymis is entirely separated and all bleeding points ligated.

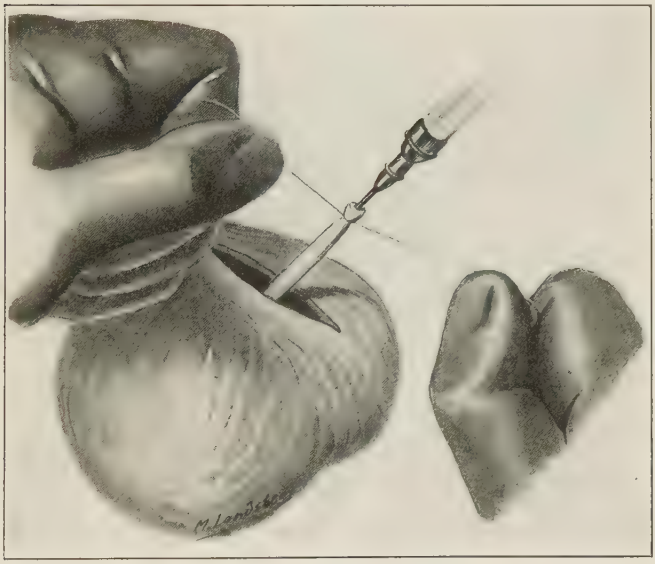

FIG. 72.—The testicle is then reduced into the scrotal sac. Carbolic may then be injected into the vas deferens if the condition is tuberculous

the epididymis, through which the tunica vaginalis is opened. If this covering is bound down by adhesions, as is frequently the case, it must be carefully dissected free before the testicle and epididymis

can be delivered through the wound. Scissors and thumb forceps are used to separate the epididymis from the testicle, this manner of dissection offering less likelihood of injury to the posterior vessels. Cabot directs that separation should be begun at the upper pole and carried downward, the epididymis being freed from within outward.

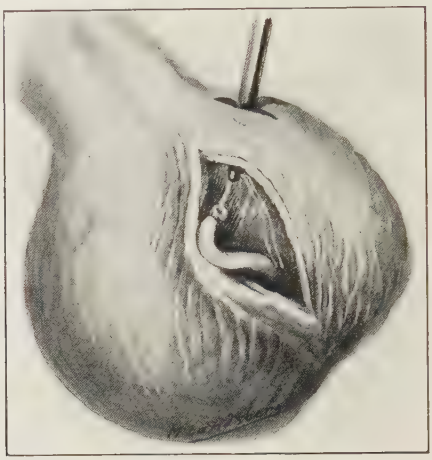

FIG. 73.—The vas deferens is brought through a stab wound away from the operative wound.

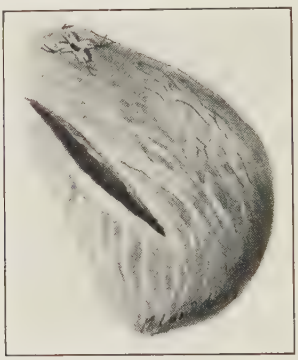

FIG. 74.—The vas deferens is sutured to the skin so that any discharge will pass out into a dressing and not into the scrotum, where it might easily infect the areolar tissue and cause a persistent sinus.

When separation is complete the lower end of the vas deferens should be dissected free from the cord for a couple of inches, and a curved clamp applied to it. After the epididymis, together with the lower 2 inches of the vas, have been excised, the vas is freed by blunt dissection with the fingers, until it is separated from the cord as far up as the external inguinal ring. Using the fingers as a guide the clamp

previously placed on the lower end of the vas is now pushed up into the canal until it has advanced as far as the internal ring. Care must be taken to avoid pushing it to the front where it would come between the fascia and the fat. When the clamp has reached the point in the canal where it lies directly beneath the fascia at the level of the internal inguinal ring, its handle is depressed sufficiently to bring its point snugly against the skin. The skin and superficial tissues are then incised over it, and the distal end of the vas carried through the wound. The vas is then picked up and traction is made so as to pull out the portion lying in the canal, so that the remaining portion dives vertically into the wound and over the brim of the pelvis. There it is freed as far as the finger can reach, then clamped and divided and, after cauterization with phenol, dropped back. The wound in the groin is closed with catgut, and the fascia with a single stitch of silkworm-gut. The operation is completed by the careful ligation of any bleeding points in the scrotum.

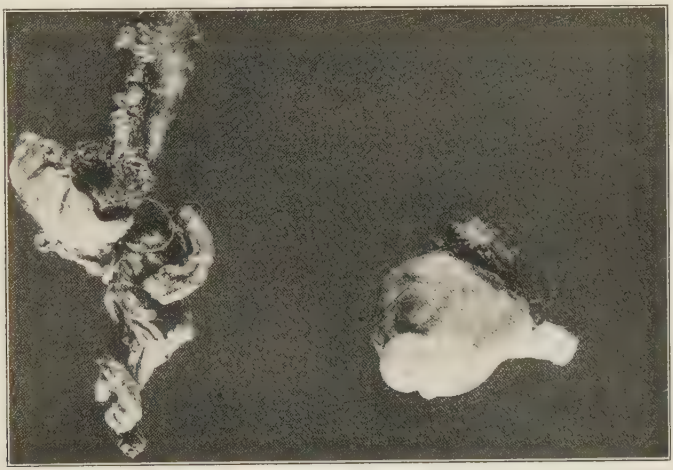

FIG. 75.—This is a photograph of a tuberculous seminal vesicle with a considerable portion of its beaded vas deferens removed with it. The figure to the right is a testicle with tuberculous globus major; the globus minor seen below is normal.

A *modification* of this procedure claimed[8] to give less chance of injury to the involved bloodvessels consists in separating the globus major from the vascular pedicle by inserting the scissors beneath the fold in that section of the vas deferens which lies in front of this pedicle, and reflecting the vas at the globus minor.

In performing an epididymectomy the authors prefer to start the operation by freeing the vas, as it helps to avoid injury to the blood-vessels. In tuberculosis the proximal end of the vas is transplanted into the skin of the groin so that any drainage will take place externally and not into the scrotum.

OPERATIONS ON THE VASA DEFERENTIA.

Vasostomy.—Belfield's Method.[8] This operation is recommended for the relief of chronic gonorrheal infections of the seminal canal (vesiculitis) with or without a "gleety" discharge; for chronic pus infections of the seminal canal in the middle-aged or elderly, a condition often mistaken for prostatic hypertrophy; for recurrent epididymitis which results from repeated invasion of the epididymis by an infection which persists in the seminal vesicles, or for an acute gonorrheal spermato-cystitis.

Technic.—The vas deferens is brought by the fingers against the skin of the scrotum and held there by a half-curved needle passed through the skin under the vas. Under local anesthesia the vas is exposed by $\frac{1}{2}$-inch incision made through the skin and the envelopes of the spermatic cord, and its canal opened by a transverse or longitudinal incision. Through this incision a blunt hypodermic needle can be passed and a solution of any desired agent injected. Vas and vesicle can usually accommodate from 4 to 6 cc. of a non-irritant liquid such as argyrol solution. None of the solution escapes through the ejaculatory duct until vas and vesicle are filled, because this exit is closed by a sphincter. This muscle yields to overflowing of the seminal ducts, the solution passing into the prostatic urethra and thence usually backward into the bladder, but occasionally forward into the anterior urethra, escaping at the meatus. An unlimited quantity of solution may thus be used to irrigate vas, vesicle, ejaculatory duct, prostatic urethra and utricle; and this irrigation may be repeated at the discretion of the operator.

The first injection into the vesicle should not exceed 30 minims; if much more is used there may be spermatic colic due to contractions of the vesicle, or even urinary retention. When the inflammation begins to subside the amount of irrigation fluid may be guardedly increased.

A suture having three functions, to guide the needle during the daily injections, to keep the lumen of the vas patent, and to close the fistula when the treatment is completed, should be passed through the lumen of the canal at each cut surface, and out through the wall of the vas $\frac{1}{4}$-inch or more distant from this cut end. One suture end is then pushed through the skin and the two ends are loosely tied on the outside. To close the fistula one has only to tighten this suture until the cut surfaces of the vas are approximated.

Kidd's Modification.—Recently Frank Kidd of London[83] published a modification of Belfield's method, which requires general anesthesia and retaining the patient in bed for four or five days. The chief advantage claimed for this more complicated procedure is that it enables one to complete the treatment within four or five days. The operation is described as follows:

Pinch up the skin at the top of the scrotum on its outer side where the dartos muscle is absent; isolate the vas from the other structures

of the cord and hold it firmly in position with the fingers of the left hand immediately under the skin. Make an incision 1 inch long directly down to the vas until its white wall is clearly visible. Seize the vas with a pair of tenaculum gland forceps and with a few strokes of the knife free it from its loose outer covering of areolar tissue, until the handle of the scalpel can be pushed beneath it. The vas must be stripped quite bare of all connective tissue before opening it, and care taken not to cut the artery which lies along its posterior wall. With a fine sharp-pointed tenetome make a tiny incision into the lumen of the vas large enough to admit the needle. Insert a strand of silkworm-gut into this incision and run it down as much as 10 inches to demonstrate that entrance is free and the vas patent. Both suture and knife should now be withdrawn and the vas slung up upon sterilized tape.

For the next step Kidd has devised a special cannula, so constructed that a guide wire will pass easily either way, and fitted with a rubber tip originally designed for renal lavage. The cannula must be nicely gauged for the individual vas to be treated, for too large a cannula "will strip up the lining membrane of the vas and stultify the operation." A syringe is attached to the cannula and 5 per cent colloidal silver used for the injection. When syringe and tip are withdrawn the cannula is left in place with a wire thrust into its lumen to keep it patent. A mattress suture of fine silkworm-gut is placed in both sides of the skin and fascial incision and beneath the vas. The tying of this suture leaves the vas slung up on a bed of connective tissue securely anchored at the level of the skin. Through rings on the cannula provided for that purpose, it is sewed in place by a silkworm-gut suture set in the skin at each side. The wound is protected with a T-bandage and the patient's legs immobilized until he recovers from the anesthetic.

On the second day the wire guide is removed from the cannula and if it is found to be patent a second injection is given. Should a preliminary filling of the syringe with sterile water fail to pass into the cannula, this should be taken out, for if the silver solution is forced in under these circumstances it will only result in infiltrating the tissues, a most unpleasant result. But if all goes well a third irrigation may be given on the fourth or fifth day and the cannula taken out. When doing this it is most important to remove the silkworm-gut "slinging stitch" and with the fingers manipulate the wound so as to loosen the adhesions around the vas and make it drop back into its proper position deeply in the scrotum. Unless this is done the vas may remain adherent to the skin wound and the opening persist as a spermatic fistula.

The authors much prefer the opposite method of approach for such cases. The use of Delzell's cannula through an endoscopic tube in the urethra allows an unlimited treatment of vasa deferentia and seminal vesicles by injections into the ejaculatory ducts.

This procedure is recommended for all cases of chronic relapsing gonorrhea (or *Bacillus coli* or streptococcal vesiculitis) in which there is evidence of thickened diseased vesicles, and the usual methods of treatment have failed to give relief; also for chronic arthritis with chronic relapsing epididymitis, as well as for arthritis in the early stages of the severe type of this affection.

OPERATIONS FOR THE RELIEF OF STERILITY.

Epididymo-vasotomy.—Martin's Operation.—Obliterating bilateral epididymitis is now recognized as a frequent cause of sterility in the male, and during the past twenty years a number of surgical pro-

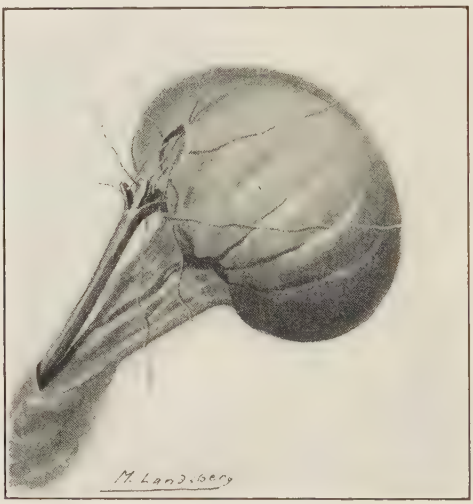

FIG. 76.—After removal of the diseased seminal vesicle the vas deferens is split so that the end is composed of four flaps. An incision is made into the upper portion of the testicle at the site of the rete testis.

cedures have been devised to remedy the azoöspermia which is the frequent sequel of this epididymal inflammation. The best known of these operations is Martin's epididymo-vasotomy, which was first published in 1902.[86] Under general or regional anesthesia an incision is made through the posterior scrotal wall, through which the vas is freed to about the level of the top of the testicle; its lumen opened and the epididymis exposed for its entire length. An incision is made in the epididymis into which the vas, cut obliquely and split upward for a $\frac{1}{4}$ of an inch, is implanted and held in place by four fine silver wire sutures. The sutures are carried from without into the walls of the vas, and from within out of the wall of the epididymis. This operation was used by various urological surgeons without modification for a long period,[100] but there appears to have been but little

general interest in any aspect of the matter, for in 1907, Hagner remarked that very few of these operations had been reported.[57]

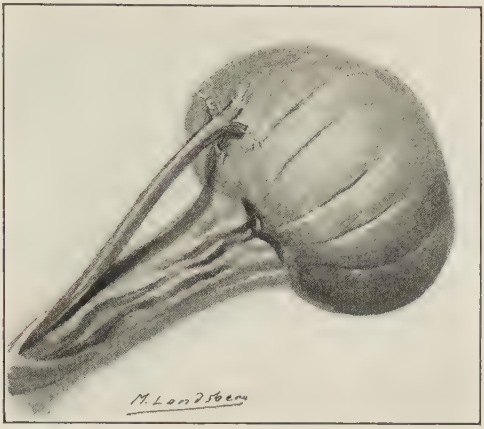

FIG. 77.—The split ends of the vas deferens are sutured so that its lumen presents directly into the incision in the region of the rete testis.

Bernart's Modification.—In 1915, Bernart[12] of Chicago suggested that lack of success in the Martin operation was not due to the vas failing to remain patent, but rather to the fact that the wound in the head of the epididymis has a tendency to close rapidly. To obviate this, after making the openings in the vas deferens and head of the epididymis according to Martin's technic, anastomosing sutures of 00 plain catgut are placed in position, and before being drawn taut, the silver wire is inserted in the proximal portion of the vas until the loop engages in the wound. The loop is then imbedded in the epididymal wound and the sutures are tied. The free end of the wire is brought out of the scrotal wound, and is so bent that upon its removal twenty-four to thirty hours later, the loop reseparates the adherent wound surfaces in the head of the gland.

McKenna's Procedure.—In 1915, McKenna[82] reported a modification of Martin's operation which he had employed upon experimental animals with success, and had used in 6 human cases, a few of which were satisfactory. Four years later he published a slightly improved technic which appears to have better results. One case at least[90] has been reported where the procedure has been successful in other hands.

Short Circuit of the Vas Deferens.—Short circuit of the vas deferens is the name given to this procedure, which is usually undertaken to repair an old gonorrheal epididymis in which there is an obstruction of the vas between the tail of the epididymis and the external inguinal ring. Previous to operation the vas should be injected in order to determine its patency between the proposed place of incision and the

FIG. 78.—Short circuit operation. Before this operation is undertaken it is determined that there are viable spermatozoa in the testicle. Incision is made in the vas deferens and methylene blue injected to determine its patency, unless this fact has been previously determined by the injection of sodium iodide and radiography. Incision is then made in the globus major. Fine silver wire is placed in the lower end of the epididymis wound and the upper end of the vas deferens incision.

FIG. 79.—Fine silver wire introduced into each side of both wounds.

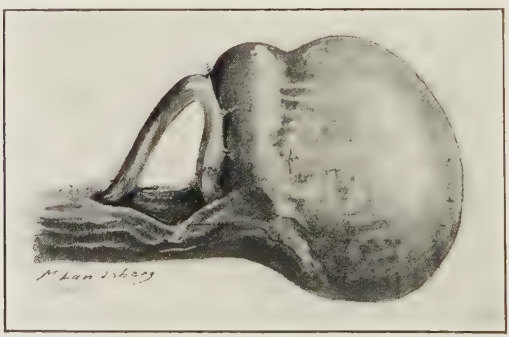

FIG. 80.—The anastomosis is completed by passing a fine silver wire through the upper end of the epididymis incision and the lower end of the incision in the vas deferens. The silver wire may be left in place. According to Hagner, it prevents infection and subsequent necrosis of the tissues.

ejaculatory ducts. If the vas is not patent, the short-circuiting operation will be useless, and Lespinasse's procedure (page 280) should be employed instead. Should there be any question of infection in the seminal vesicles it should be treated by irrigation through the ejaculatory ducts and the short-circuiting deferred until the infectious condition has cleared up.

The patient is prepared in the usual manner (except that tincture of iodine is not allowed to touch the scrotum for fear of producing excoriations) and placed in a modified Trendelenburg position. An incision over the vas about 2 inches above the testis is made, exposing the vas and epididymis. The vas is separated by palpating the cord between the finger and thumb. A tenaculum or vorsellum forceps is placed about the cord at its juncture with the epididymis, and a silkworm-gut suture passed beneath the vas 3 or 4 inches above the forceps, thus fixing the cord, and giving easier entrance to the vas.

By gauze dissection and the Kocher director, the vas deferens is stripped of its covering for 2 or 3 inches above the epididymis, and a $\frac{1}{2}$-inch incision made into its lumen with a fine-pointed bistoury. Through this incision 10 per cent argyrol solution is injected. If the lumen is patent, black urine can be withdrawn from the bladder. A small silver wire is introduced into the lumen with about 4 inches of its length exposed at the incision. Four sutures of small silver wire are placed through the incision in the vas and brought down into the opening in the epididymis. The free end of the wire is brought through the point of anastomosis with the epididymis and out through the skin opening. The epididymis is opened at its upper third.

The skin is closed in the usual manner, and the wire is at first protected by gauze, but is withdrawn after four or five days, its purpose being to keep the lumen from becoming clogged with blood clot. Should clots form and organize the operation will be of no value. The section of epididymis used must be demonstrated to contain free spermatozoa, and the globus major must be employed for its implantation.

Direct Vaso-epididymostomy.—An operation for the relief of sterility by direct anastomosis between the epididymis tubule and the lumen of the vas was described by Lespinasse in 1918.[73] An incision into the tunica vaginalis of the testicle exposes the epididymis and the point of obstruction is noted. The lumen of the vas is opened by a short longitudinal incision and a colored fluid injected into the central end of the vas. The appearance of this fluid in the urethra shows that the vas is open from the point of incision to the urethra. The epididymis capsule over that compartment directly above the obstruction is incised down to the tubules, great care being taken that all the different layers of the capsule are removed from the epididymis tubule, and that the tubule itself is not nicked or cut at any point. The tubule will protrude through the opening thus made. The tubule selected should have the same direction as the long axis

of the body of the epididymis. A No. 19 bayonet-pointed needle, threaded with 00000 silk is passed through the wall of this tubule, down its lumen, and out again through the wall at a point 2 to 4 mm. from where the needle entered. The outpouring of epididymal secretion which follows the needle is aspirated into a small syringe and later examined for spermatozoa.

The ends of this crown, or epididymal stitch are now passed through the longitudinal incision into the vas, down its lumen and out through its wall. Very fine catgut sutures are passed on either side of the longitudinal incision in the vas, including both wall and epithelial lining, their purpose being to hold the incision open. Other sutures including only the wall and not entering the lumen, are set a short distance from each end of the incision. They are so placed to fix the vas to the epididymis and support the weight of the testicles, and are so spaced on the length of the vas that when they are tied down they leave the intervening vas slack, so as to remove all tension from the union between the epididymis tubule and the vas. The central or upper end of the crown stitch is now threaded on a long Hagedorn needle which after replacement of the testicle carries the crown thread out from within the scrotum. This suture can, within a fortnight, be removed by gradual slow traction.

Anastomosis of the Vas Deferens.—The vas deferens is sometimes accidentally severed during operation for inguinal hernia, and may also be torn apart when the scrotal content is extensively traumatized. This is, under any circumstances, a decidedly grave lesion for, as has been pointed out[105] the small size of the vas deferens renders it technically difficult to make an anastomosis with any degree of accuracy of approximation. Yet because of the peculiarly active regenerative capacity of the epithelium with which it is lined, repair of these accidental defects is secured with greater frequency than one would suppose possible.

Approximation of Squared Ends with Protective Sheath.—Many years ago Lydston[79] proposed to cut both ends squarely off; to make a hole through the wall of the vas about $1\frac{1}{4}$ inches from the cut end, by means of a sharp-pointed probe or long-rounded needle; to pass a strand of large-sized silkworm gut or a filiform bougie into the proximal end of the vas and bring it out at the hole made by the probe or needle, drawing the thread through until a length of about 3 inches protrudes; to thread the other end of the strand of silkworm gut into the distal portion of the vas, and finally to "draw the two severed ends together over the coupling thereby formed." The edge of the sheath enclosing the cord is rolled about the vas and stitched into position to make a protective covering for the anastomosis, and the opposite edges of the fascia are drawn over to this sheath by a continuous suture of fine catgut.

Anastomosis by Invagination.—Another method of suture[36] is that adapted from Poggi's method of anastomizing the ureter. The proxi-

mal end of the divided vas is cut off obliquely so as to have a moderately long-pointed extremity, while the distal end is given a "short bevel" of about forty-five degrees. Ordinary fine sewing needles are threaded on each end of a strand of fine catgut; one needle is passed through the tip of the proximal end, then into the lumen of the distal end, and is finally pushed through the wall beyond the opening. The second needle is directed in the same way, and brought out close to the first. Traction on the threads now draws the pointed proximal end of the severed vas into the lumen of the distal end until its apex reaches the point where the needles emerge. The thread ends are then tied, and two additional sutures of fine catgut are placed to fix the extremity of the distal end to the side of the proximal end. In making the anastomosis, care should be taken not to make the pointed bevel on the proximal end too long, and also to introduce the needles nearly or quite their full length before piercing the side of the tube. The object of these two precautions is to separate as far as possible the two openings in the proximal and distal ends.

"Needle Splint" Method.—A method more recently suggested[115] is the following: The point of an ordinary No. 6 or 7 sewing needle is passed into the lumen of one severed end of the vas; the needle carried up a distance of perhaps ½-inch, and the point then thrust through the wall, where it is seized on the outside by a hemostat. The eye end of the same needle is then passed into the lumen of the other severed portion of the vas, and the ends are brought together, the needle thus serving as an internal splint. Three or four sutures of fine catgut or silk taken with a very fine straight or curved needle, are used to unite the severed ends of the vas. The "splint needle" is then withdrawn by means of the hemostatic forceps attached to its point.

Vasoligature.—Steinach's Operation.—Ligation of the vas deferens has been performed for various indications for a considerable period, occasional mention of it being made in urological literature since the opening of the present century. The indications most often mentioned are relapsing epididymitis and spermatorrhea in subjects of advanced age. No especial attention was accorded the procedure however, until in the year 1920, Eugen Steinach of Vienna published the first account of his studies in the effects of vasoligature upon experimental animals (rats), and a small series of human subjects. The operation as performed by Steinach is based upon the assumption, first put forward in 1903, by the French investigators, Bouin and Ancell, and now generally accepted, that the sex glands contain not only generative cells which produce ova and spermatozoa, but also a glandular portion made up of interstitial cells, the function of which is to influence the secondary sex characteristics. Definite proof of this theory was wanting until 1912, when Steinach after experimentation, demonstrated that these interstitial cells had an

important relation to the development of the individual, and applied to that portion of the sex organ which was productive of this influence the term "puberty gland."

Following up his observations that active proliferation of the interstitial cell portion of the sex gland is necessary for the maintenance of the individual's functional vitality, Steinach endeavored to demonstrate that senility could be retarded by artificial production of this proliferation, or even that functional activity could be restored to senile individuals in whom this proliferation had diminished or altogether ceased. At first employing homo-transplantation, he later discovered that the same effects could be gained by ligation of the vas deferens in the male. Ligation of the vas destroys the generative function of the testicle to which it corresponds, but observations upon animals showed that while the generative portion of the testicle atrophies, the interstitial portion immediately undergoes a compensatory activity. Moreover, if the opposite testicle is normal both portions of it are likely to become more active, so that an individual undergoing vasoligature on one side only may not be rendered sterile, and may even experience a renewal or increase of sexual potency on the unoperated side.

Technic.—An incision from 4 to 6 cm. in length is made directly above the cord and in a parallel direction, at that point close to the root of the penis where the cord can be easily palpated. The incision is carried down through the intervening tissues until the cord is fully exposed. The artery, veins and nerves surrounding the vas are carefully dissected from it, the greatest care being exercised not to injure any of the vessels, especially the tiny artery which lies close beside the vas itself. The vas should be entirely denuded for a distance of some 3 cm., and a ligature placed at either end. It has been recommended that a second ligature be placed $\frac{1}{2}$ cm. below that on the distal end, as the first may be loosened by peristalsis of the vas.[10] The vas is resected between the ligatures, a section about 2 cm. in length being removed, and the proximal stump is brought to the upper end of the wound and attached to the tunica vaginalis, so as to retain the testicle in suspension. Closure is effected as in other operations in this region.

Indications.—Most authors agree that definite indications exist for the operation of vasoligature in certain well-defined conditions, involving the testicle on the one hand and the prostate on the other. In chronic relapsing epididymitis which has resisted other measures of treatment, it has been found that severing by vasoligature the link which so closely connects prostate and testis will serve as a means of removing the latter gland as a constant menace of complicating inflammation. There is a certain percentage of prostatic cases, accompanied by enlargement and obstructive retention that, when properly selected, yield a prompt and satisfactory response to the decongesting influence of double vasoligature. This is at a time

of life when the question of procreation no longer exists. The favorable effect of this operative technic is most pronounced when for various reasons it is deemed inexpedient to attempt the major procedure of prostatectomy; but the fact must be emphasized that disappointment is likely to be the result, unless the cases submitted to this minor procedure are carefully chosen.[20]

It is the opinion of those in this country who have made a careful investigation of the claims made for this operation by enthusiasts abroad that while many of these claims are extravagant and without foundation, the fact remains that "*senium præcox* an indefinable state of the organism, induced by psychic or physical wear and tear, has, as a result of vasoligature, been succeeded by a re-awakening of psychical activity and an improvement in physical vigor that, previous to this operation, seemed beyond reasonable expectation."

OPERATIONS UPON THE SEMINAL VESICLES.

Anesthesia.—In operative procedures upon the seminal vesicles, the choice of an anesthetic is of very great importance. For the past three years the authors have employed sacral and parasacral anesthesia for interventions upon the vesicles, and the results have been highly gratifying. To many subjects coming to operation the use of ether is contraindicated, when pulmonary tuberculosis is present for example, and local anesthesia applied anywhere in the region about the anus is decidedly dangerous owing to the impossibility of rendering this area surgically aseptic. If sacral anesthesia is employed this danger need not be feared. The technic which we have employed is fully described under prostatectomy (page 443), the procedure being similar in all respects when the seminal vesicles are the site of operation.

Vesiculotomy.—Indications.—Indications for intervention upon the seminal vesicles have already been discussed (page 245). Practically all the operative procedures now in use are founded upon the work of Fuller, who from the beginning of the present century has made invaluable contributions to the entire subject of seminal vesicle surgery. His original method of vesiculotomy consisted in exposure of the vesicle by means of a free longitudinal incision which permitted drainage of the sac cavity, currettage and the removal of intravesicle neoplasms, or drainage of a perivesicular abscess. If inflammatory adhesions were present it was also possible to carry out peripheral dissection to free the organ, "a sort of decapsulation, as it were."[50]

Fuller's Procedure.—A long lateral incision is made on either side of the anus, and these are joined by a transverse incision directly in front of the anus. The incision thus made is of sufficient size to allow the operator to work in front of the rectum without endangering it, and to separate the tissues lying above the perineum by blunt dissection until he arrives at the prostate, and is able to expose the vesicles which lie on either side of that gland. Incision of the vesicle for

currettage or drainage, or if necessary, vesiculotomy, can then be easily carried out.

A semilunar or inverted V-incision is preferred by other operators[108] who then expose and divide the median tendon, open the fossæ on either side by blunt dissection and divide the recto-urethral muscle. The fascia is then picked up with a tenaculum and incised first over one vesicle, and thereafter, punctures or incisions into the vesicles or their diverticula made in accordance with the requirements of the conditions exposed.

Still another procedure[113] is carried out with the patient in the exaggerated perineal lithotomy position. The skin incision is the inverted U-shaped one used in perineal prostatectomy, the apex being at the mid-perineal point with the lateral arms extending toward the ischial tuberosities. Retraction of the skin flap downward exposes the median perineal tendon, before division of which the fossæ on either side are opened by blunt dissection which is carried out close to the bulb and away from the rectum. Before dividing the recto-urethral attachments, blunt dissection is carried on until a finger introduced into either fossa can feel the posterior surface of the prostate, and by "gentle burrowing" enter the fossa of the other side, so that it can be "hooked around" the upper limit of the muscles which attach the urethra to the rectum, enabling the operator to divide these attachments close to their point of insertion into the urethra. The dissection between the rectum, prostate and bladder base should be thoroughly done, and carried out "until the sulcus between the vesicles is easily appreciated by touch." A deep flexible ribbon tractor with a folded piece of gauze between it and the rectum, is now placed in the wound, and two traction sutures of heavy silk threaded through the tissue where the bases of bladder and prostate come together. If downward and forward traction is now made upon these threads, the floor of the bladder with the vesicles in their fascial covering will be brought into better view. The fascia is taken up with mouse-tooth forceps and carefully snipped, any opening into the vesicle being avoided until it has been freed from all inflammatory adhesions, and the enveloping fascia widely divided.

Cunningham[34] makes a similar dissection, but when the junction of bladder and prostate is reached the rectum is protected by a piece of gauze in the bottom of the wound, and "a flat retractor either $1\frac{1}{2}$ or 2 inches in width, according to the width of the bony pelvis, with an abrupt curve and long enough to reach the bottom of the wound, is inserted. This special retractor is furnished with a weight so that it is self-retaining; a special double tenaculum is inserted into the prostatic tissue just below its junction with the bladder. By lifting the prostate with this instrument the base of the bladder and the vesicles may be visible beneath the fascia of Denonvillier, provided this fascia is not much thickened by inflammatory exudate." The vesicle should not be opened by multiple incisions, but by cutting

away the posterior wall. Exposure of the vesicles is accomplished by dividing the fascia of Denonvillier along the superior border of the prostate and stripping it back as a whole, rather than exposing it over each vesicle separately.

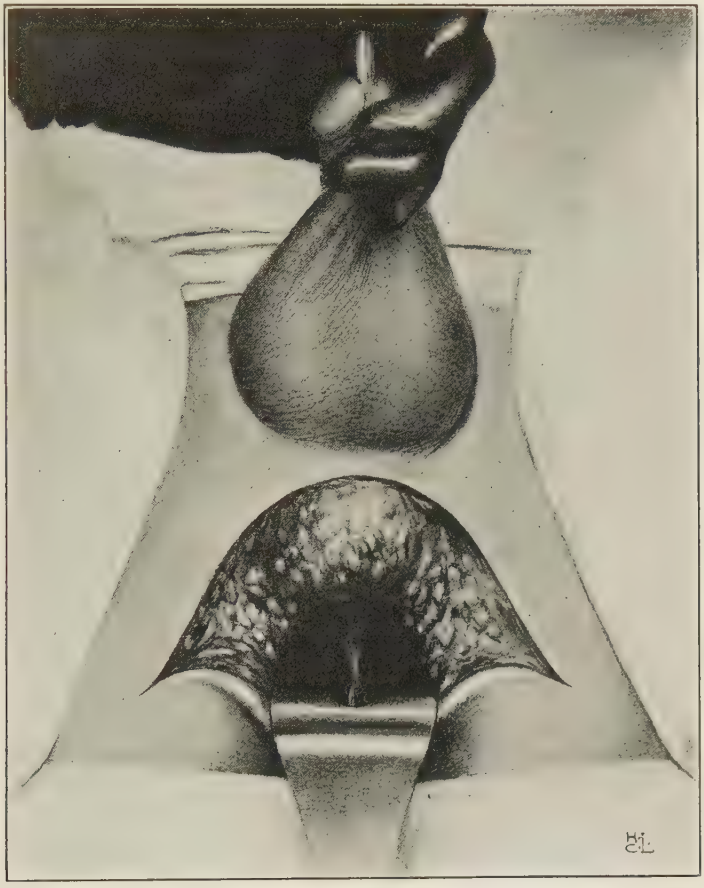

Fig. 81.—Exposure of central tendon with bifid posterior retractor in position.

Seminal Vesiculectomy.—The author's method is a combination of the procedures described by Young[140] in 1913, and Squier[114] a year later, with additions and modifications which have been added as a result of our experience at the Brady Foundation. This operation was described by Morrissey and Smith[92] in detail a short time ago, at which time they claimed for it "a number of new features and conservative modifications which contribute largely to the safety of the operation and are effective in diminishing unfavorable after-results and at the same time aid in a better exposure of the operative field."

Technic.—After suitable anesthesia (see page 443) the patient is placed well forward upon the table, with the sacrum elevated and the buttocks projecting beyond the edge. A sound is placed in the urethra, and by palpation upon it, the lower limit of the bulbous urethra is accurately determined. A crescentic incision is then

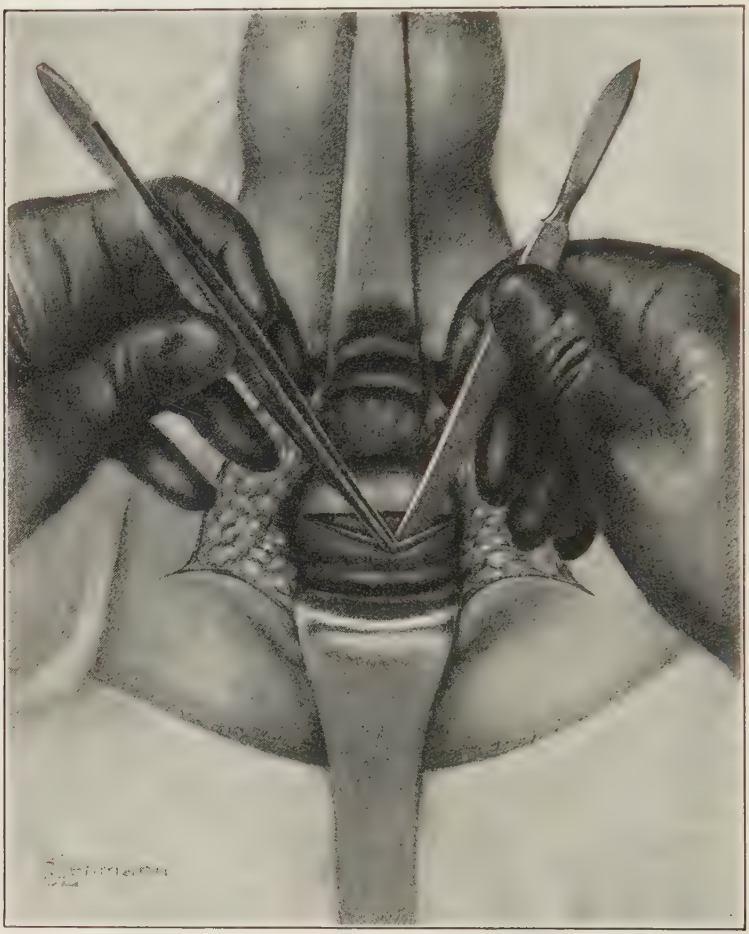

FIG. 82 (Morrissey and Smith).—The triple-layered fascia is incised transversely at the base of the prostate.

made beginning at one ischial tuberosity, carried in an upward curve through a point just above the termination of the bulbous urethra, where it should be at least 1 cm. in depth, to the opposite ischial tuberosity. The central perineal tendon is exposed, separated from the lateral fossæ by blunt dissection and sharply divided, care being taken to retain all the bulb fibers in the upper part of the wound, thus

reducing hemorrhage with consequent clouding of the field. The usual seminal vesicle tractor is now inserted, the apex of the prostate is brought forward and elevated with this instrument, and with a finger in the rectum, the attachments of the recto-urethralis muscle are separated by sponge dissection; especial care being exercised to avoid injury to the rectal wall. The muscle fibers should be stretched by gentle tension upon the skin flap aided by the finger within the

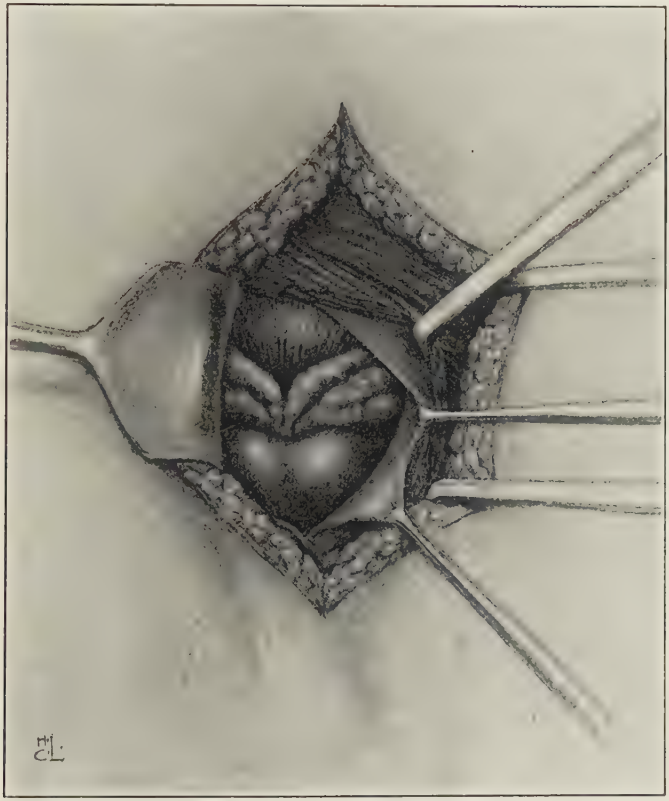

FIG. 83 (Morrissey and Smith).—Denonvillier's fascia and Lowsley's fascia removed showing the prostate and seminal vesicles with the ampullæ of the vasa deferentia. The base of the bladder is seen between the ampullæ.

rectum, so that they are easily cut with scissors close to their urethral insertion. The remainder of the anterior surface of the prostate is brought into view by gauze dissection, and the visible free edges of the levator ani should be carefully detached by the finger and lifted from the wound. The posterior surface of the prostate is cleared of any adherent tissue fibers, after which retraction of the gland makes possible a transverse incision just behind its middle axis, the incision being so directed as to avoid severing any engorged vessels which

may be visible. The several layers of the fascia described by Lowsley should be identified and separately incised and stripped back. The vesicles can then be palpated by passing the tip of the first finger in front of the fascia and extending it outward along the posterior surface of the prostate.

The operation of freeing the vesicle should begin at its tip, any adhesions to the bladder base and vas deferens being separated as

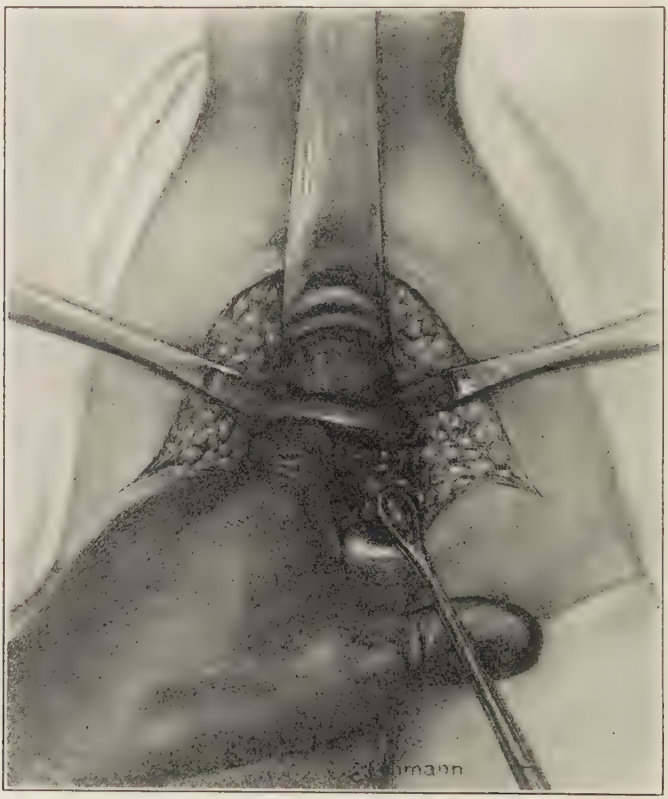

FIG. 84 (Morrissey and Smith).—One seminal vesicle is shown being held by its tip. It is well to deliver both seminal vesicles before excising either as it simplifies the procedure. Traction on the delivered vesicle makes it easier to dissect the second one.

the dissection descends. The entire organ may be brought under direct vision by inserting a holder with a gauze sponge into the post-prostatic space. When freed, the vesicle is crushed and removed. Ligation is not usually necessary, but the prostate must be freely incised and suitable drainage instituted. After withdrawing the urethral sound, the edges of the levator ani are loosely sutured, the muscle drawn down over the prostate and the central tendon reunited. A tube is brought out on either side of the skin incision, which is

then closed with silkworm gut sutures, the tubes being left on either side of the central part of the wound, thus effectively draining the operative field.

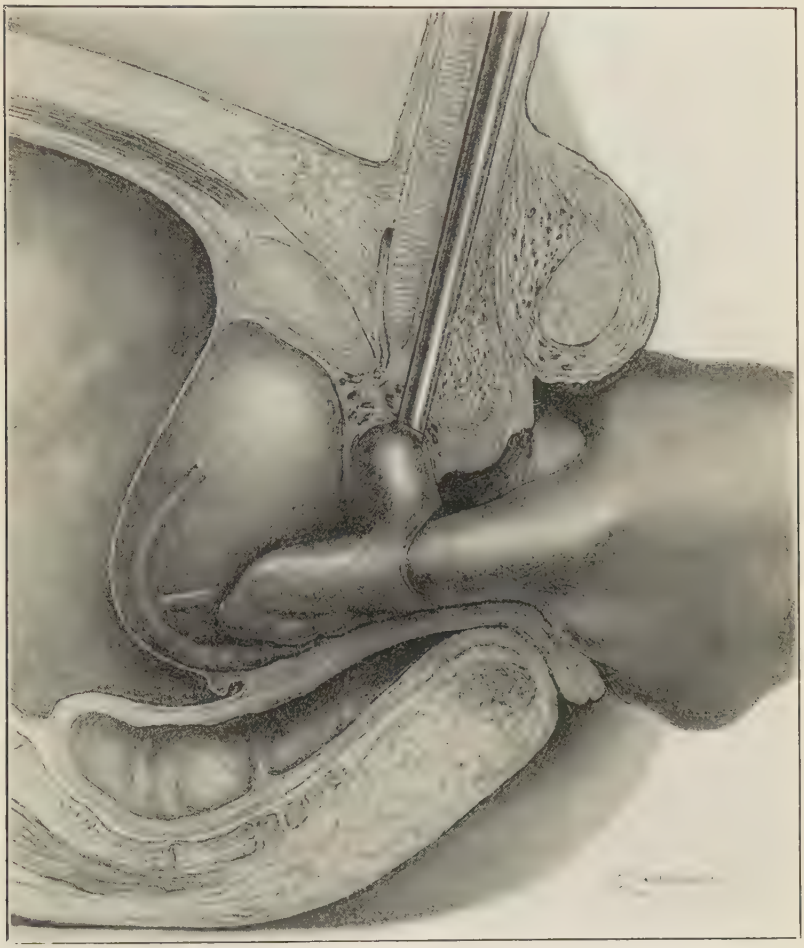

FIG. 85 (Morrissey and Smith).—Sagittal section showing the finger inside the envelope of the seminal vesicles dissecting them out.

Cauterization and Curettage. Some operators have treated extensive seminal vesicle inflammation by opening the posterior wall of the affected vesicle, excising a greater part of the tissue and cauterizing it with crude phenol, the whole area being subsequently swabbed out with alcohol. We do not recommend this procedure, for in cases where drainage alone will not be sufficient, complete excision of the vesicle is much to be preferred.

Complications.—Injury to the rectum is perhaps the most serious operative mishap likely to occur, and the careful replacement of this organ in its normal position is very important. The bladder and perineal cavity may also be entered, and epididymitis is a not uncommon postoperative complication. Careful support of the scrotum should be instituted, and if this detail receives proper consideration inflammation of the epididymis is unlikely to occur.

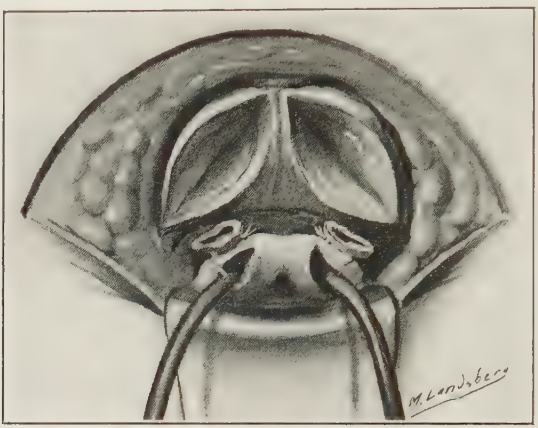

FIG. 86.—The seminal vesicles have been ligated and excised. Small tubes are sutured into drainage wounds of each ampulla. Wide incision is made into lateral lobes of the prostate for the purpose of drainage, care being taken to avoid injury to the ejaculatory ducts.

Cunningham advocates the insertion of a rubber tube covered with iodoform gauze, as a long plug, into the rectum as a final operative step. Its purpose is to obliterate the area of operation and control any oozing, and also to permit the escape of gas during the period that the bowels are confined. The patient should be informed that he will probably be sexually deficient for a period of from three to six months after seminal vesiculectomy. This is not always the case as one of our patients had intercourse the day after leaving the hospital, two weeks after operation.

SURGICAL TREATMENT OF GENITAL TUBERCULOSIS.

Tuberculosis is so rarely confined to any one part of the genital canal that its surgical treatment usually involves intervention upon several different structures. Though most students of the subject affirm that the primary lesions are oftenest found in the epididymis it is not long before the testicle, vas deferens, seminal vesicles, prostate and even the bladder and urethra become involved. From the bladder it is an easy step to the kidney.[136] It is therefore, evident that in order

to live up to its name, radical operation must include a very extensive eradication of the diseased area.

Young's Procedure.—In our work we have followed the procedure about as outlined by Young.[141] The membranous urethra and apex of the prostate are exposed through a U-shaped perineal incision, with division of the central tendon and recto-urethralis muscle. Leverage and pressure exerted upon a tractor inserted in the bladder through the membranous urethra force the prostate and seminal vesicles up into the wound, and the fascia of Denonvillier is uncovered by drawing the levator ani muscle outward and backward with the rectum. The superficial layer of this fascia is divided near the apex of the prostate, thereby exposing the deep layer, which is opened by a Y-shaped incision. By elevating the fascia on both sides, the lateral lobes of the prostate, the ampulla and the seminal vesicles are exposed, and the central portion of the prostate immediately beneath the urethra and the site of the ejaculatory ducts, is left intact, as well as being protected by fascia. This exposure gives an ample view of the affected structures and enables the surgeon to determine whether the disease is unilateral or bilateral, and whether one or both lobes of the prostate should be excised.

The vas is freed up to the point where it winds around the ureter, clamped and divided; the seminal vesicle of the same side freed and firm adhesions clamped and ligated after division to prevent bleeding; the vesicle and ampulla freed from above downward until the joining point with the upper portion of the prostate is reached. If necessary a portion of the prostate may be removed through an incision which divides the ejaculatory duct about 5 mm. from the urethra, care being exercised to leave tissue enough to prevent the occurrence of a urinary fistula. After this, the prostatic tissue is easily removed by enucleation from within its capsule, and the fascia, ampullæ, seminal vesicle and lateral lobe of the prostate are thus removed in one piece. In bilateral cases, identical procedures are carried out on both sides. The wound is partly closed in the same manner as for prostatectomy, provision being made for drainage, and long clamps being left attached to the upper ends of the vasa deferentia to be used for traction a little later.

With the patient in the dorsal position, the thighs well separated, an incision is next made along the cord, just below the external ring, the testicle delivered through a division in the dartos; separation of the vas and epididymis from the veins and testicle accomplished through an opening in the tunica vaginalis, and finally, division at the upper end of the epididymis made with a cautery. Hydrocele formation is obviated by suturing the tunica vaginalis behind the testicle, and the testicle and veins returned to the scrotum. That part of the vas not previously freed is loosened by traction exerted by the assistant upon the clamp left upon its lower end during the early part of the procedure, alternating with traction by the operator

upon the vas in the groin. When liberated, the vas can be easily drawn out through the groin.

A *slightly different procedure* was originated by Pauchet in 1909, and called to the attention of European urologists by Legueu in his *Traité chirurgical d'Urologie*, published in 1910. Whiteside, who employed this method of dealing with genital tuberculosis before he became aware of the work of the French operators, thus describes it:[135]

The testicle is removed through the usual inguinal incision. The cord is then freed from the surrounding tissues as far into the inguinal canal as possible, and there clamped and cut off; adhesions around the vas will prevent the cord from being pulled out at this time. Shifting the patient to the lithotomy position, a semilunar incision is made, its convexity extending between the tubera ischii. After dividing the central tendon of the perineum, the rectum may be pushed backward and by blunt dissection, following the plane of the retro-vesical fascia, a deep pyramidal-shaped wound is opened up, giving easy access to the prostate and seminal vesicles. By pushing the finger up to the apex of this deep wound, and at the same time bearing down upon the forceps which has been previously clamped to the cut end of the vas deferens in the inguinal canal, this clamp can be pushed through into the perineal wound, carrying the cord with it. By removing this anterior clamp and replacing it with another applied through the perineal wound, it is possible to extirpate the entire vas and ampulla with the seminal vesicles on the same side, and the lateral lobe of the prostate. It is important not to perform the prostatectomy first.

When all the tuberculous tissue which can be reached has been removed, the anterior wound may be closed without drainage, and that in the perineum sutured about a small gauze drain.

Results of radical extirpation, as reported by a number of operators, and in our own experience, have been, on the whole, encouraging. Advanced genital tuberculosis is in itself a very grave condition, and when complicated, as it often is, by pulmonary tuberculosis, the outlook for these patients is a dubious one at best. But inasmuch as it offers practically the only hope to men in the prime of life, at an age when their value to society and to the state is at its maximum, the operation should be undertaken whenever it is not distinctly contraindicated, and its increased employment will undoubtedly prolong many lives which would otherwise be terminated just at the threshold of their usefulness.

PALLIATIVE TREATMENT.

Non-surgical Treatment of the Testicles. *Suspension in Inflammatory conditions* by various methods has already been mentioned (page 207) in connection with conditions affecting the scrotum. In many cases of orchitis and epididymitis the patient is unwilling or unable

to stay in bed, and the question of proper support for the testicles looms very large in the plan of treatment to be adopted. Where the patient is confined to bed, continuous gentle pressure by the use of a rubber bandage should be employed after the extreme tenderness present during the first few days of an acute testicular inflammation, has somewhat subsided. A strip of rubber elastic bandaging, such as is used for the extremities, about 7.6 cm. (3 inches) wide by 15 to 18 cm. (6 or 7 inches) long, is needed. A strip of adhesive plaster, about 1 inch wide and 6 inches long, is attached to one end, the plaster being allowed to overlap the rubber for a distance of $1\frac{1}{2}$ inches or more. The swollen gland is isolated from its unaffected fellow, and wrapped around with the rubber bandage as tightly as the patient can comfortably endure, the bandage being fastened in place by means of the adhesive strip. The line of greatest pressure must correspond to the most swollen part of the testicle, or as Keyes has it, "Make the adhesive plaster encircle the organ above its equator, for otherwise it will promptly slip off." The pressure must be constant, but care is necessary to avoid too great constriction. This should quickly reduce the swelling so that the patient may leave his bed if the testicles are properly supported.[19]

Other Supports. Besides the methods of support which we regularly employ, others which have given satisfaction under more or less exacting conditions, may be mentioned. An efficient way of applying guaiacol to ambulatory patients which combines testicular support is as follows:[29]

With the patient prone, the hair is first clipped away and the scrotum elevated, in order that the blood supply may be depleted as much as possible. A sheet of absorbent wool sufficient to completely cover the external genitals is cut, long enough to reach from the perineum behind and project well over the cord in front. A smooth strip of wool is placed between the penis and the abdomen, or the cord strip is so cut as to approximate there, care being exercised not to make the part of the penis protrusion too large. As soon as the medicament is applied the entire scrotum should be quickly covered, the perineal portions of the absorbent wool being carried well under the scrotum, while the opposite or cord ends can be held by the patient, thus supporting the testicles until the operator has covered the wool with oiled silk or gutta percha. Work the suspensory from the perineal region forward over the entire mass, but while doing so avoid wrinkling the scrotal covering; slip the penis through the opening in the suspensory, pass the waistband about the body, buckle backstraps, and then draw the waistband as snugly as possible, thus elevating the entire scrotal content against and upon the pubis. This maneuver, if properly carried out, will relieve the cord of all traction.

A satisfactory suspensory bandage which has been used in the British Army and can be easily extemporized is made as follows:[134]

At a point 8 inches from the long border of the suspensory bandage usually supplied to the army, cut a slit parallel with the border just

large enough to admit the scrotum and penis of the individual to be fitted; tie the folded border around the pelvis so that the lower edge of the aperture is well up in the perineum. Raise the point of the bandage, mark where the root of the penis comes, and there cut a small round hole for the penis. The support is completed by passing the penis through the last hole and pinning the point to the waistband with one safety pin. Two pleats are needed to get the necessary adjustment, and cotton wool, either plain or medicated, graduates the pressure and makes a comfortable bed for the inflamed organ.

Radiotherapy in Testicular Tuberculosis.—There is very little in the literature concerning the use of roentgen-ray therapy in tuberculosis of the testicle and epididymis, so that one gains the impression that its value is not generally recognized. Yet as far back as 1904, we find the statement:[13] "A palliative treatment which seems to have great promise in it, is that held out by the use of roentgen-rays, radium and the fluorescent solutions. In tuberculosis of the skin and glands the favorable results of this procedure promise much for the cure of tuberculosis of the testicle. . . That other glands infected with tuberculosis can be restored to normal by this means is proven, and is suggestive of help for the same disease in the genito-urinary organs, and more particularly the testicle."

The year following this suggestion, a case was reported where the roentgen-ray was employed with excellent effect upon a patient who had previously lost the left testicle because of tuberculosis. One hundred and twenty-six treatments of ten minutes each were given over a period of ten months. A medium tube was used at a distance of about 10 inches. The first application relieved the pain. The swelling and tenderness also gradually subsided until at the time of the last treatment the testicle was apparently of normal size and in normal condition.[38]

Great improvement in roentgen-ray technic and an even greater advance in our knowledge of the functions of the testicle, have taken place in the past twenty years, but both have but served to enhance the value of roentgenotherapy in genital tuberculosis. It is now known that the roentgen-rays have a sterilizing effect upon the generative organs, but there is no evidence to show that they in any way inhibit the production of their glandular secretions. Advanced tuberculosis of the testicle will render that organ incapable of producing spermatozoa, so that the roentgenologist when applying his treatment to an individual so afflicted, need not consider the sterilizing effect of the rays. Surgical removal, however, means not only the loss of procreative power, but it also entails the abolition of an important factor in physical and psychic balance, and may frequently be followed by serious constitutional and mental disturbance. The realization of this fact alone, would show the value of roentgen-ray treatment as an alternative to surgery in carefully selected cases. It is especially applicable to that stage of the tubercular process where caseation

is taking place, together with sinus formation. It may profitably be applied earlier in those patients whose seminal fluid has been demonstrated to contain no live spermatozoa. This procedure has been lately used and recommended both in this country,[64] and in Europe.[128]

Heat Treatment of Epididymitis.—It is a general observation that the external application of heat by means of hot-water bottles, electric pads and so on, while it may be a useful adjunct in the treatment of gonorrhea or other epididymitis, has no effect that can be in any way reckoned as curative. It is known that the gonococcus perishes in conditions, such as an intercurrent infection, where the body temperature rises higher than 100° F. and remains at this level for any considerable period. The reason why external applications of much higher temperature fail to destroy the organism resides in the fact that though the heat is transmitted to the epidermis, the activity of the circulation prevents it from coming in contact with the organisms deep in the tissues for a length of time sufficient to affect their destruction.

Infrared Light.—Diathermy has however, been made a more efficient and practical curative agent by several devices recently placed at the disposal of the medical profession. One of these is a series of appliances for the production of infrared light. Radiant light penetrates the tissues to depths of from 4 to 6 inches, the infrared rays of the invisible spectrum penetrating to the greatest depths by transformation of energy; radiant energy is converted into heat units in the structures beneath the skin to considerable depths, even through layers of bone.[111] The physical principle that reflection from the walls of a hollow wedge will effect total absorption of radiant energy, is utilized in the construction of applicators which are designed to meet the special needs of the urologist.[18] These implements give off a large volume of infrared light capable of deeply penetrating the urethral tissues and there setting up a hyperemia sufficient to destroy the gonococci embedded in these tissues.

Application of the D'Arsonval current to the inflamed epididymis has been made possible by the device which has been recently described by Corbus.[25] This consists of a clamp with curved arms, one of which is movable, concave discs 4 by 5 cm. in size, being attached to the distal ends of the arms. Each disc is connected with a binding post so that bipolar current may be applied, and are self-adjusting so as to be applicable to any size of scrotal content. By encasing the entire body of the testicle and epididymis between the apposed electrode surfaces, heat can be made to penetrate the deep tissues, and by maintaining it at a temperature as much above 106° F. as the patient can endure for a period of forty minutes, the gonococci can often be destroyed by one application, providing the case comes under observation in the first twenty-four hours of the epididymal involvement. Even in those instances where the inflammatory reaction has been

present for a number of days, three or four successive daily treatments have served to completely eliminate all untoward effects.

Injections Through the Vasa Deferentia. In discussing Belfield's operation (page 246) the subject of injection of the vas has already been discussed. The same drugs may be used in this procedure which the operator is accustomed to employ in routine urethral treatment, but at present the opinion is prevailing more and more that mercurochrome-220 is unsuited for use in the vesicles. There can be no invariable rule as to the number of injections to be given. That will depend upon the patient's natural resistance, the virulence of the invading organism, or the chronicity of the infection.[70]

Vas Puncture. It must be kept in mind that vasotomy and vas puncture are two entirely distinct procedures. Vasotomy involves not only isolation of the vas, but also a real opening into its lumen with its attendant dangers of infection and stricture, or possible sinus formation. Vas puncture consists of a simple puncture of the slender tube with a fine needle, which permits the injection of the desired medicament without in any way compromising the lumen of the vas.[31] It does not, of course, afford any drainage.

Injection of the Ejaculatory Ducts.—Direct application of drugs to the inner surfaces of the vesicles may be accomplished through catheterization of the ejaculatory ducts. This is possible when employing such an operating urethroscope as that of Greenberg,[55] or any ordinary urethroscope may be pressed into service in conjunction with a special two-pronged catheterizing device which we owe to the ingenuity of Dr. H. H. Young. He has also caused to be constructed several kinds of probes. filiforms and bougies of metal and whalebone which he has employed in conjunction with Geraghty's utricle syringe to explore and treat the interior of the ejaculatory ducts, the vasa deferentia and the seminal vesicles.[143] Systematic dilatations, done at weekly or bi-weekly intervals, have sometimes brought about almost immediate relief of chronic pain and discomfort, in the region of the ejaculatory ducts. The authors much prefer the use of Delzell's instrument in the treatment of the seminal vesicles through the ejaculatory ducts.

Other Methods of Reducing Vesicular Inflammation.—Hot Rectal Douches.—Hot rectal douches often prove useful in the handling of seminal vesiculitis, especially when used in connection with massage. The rectum is capable of enduring a high degree of heat applied in this manner, and one can frequently obtain results by the use of moist heat which cannot be otherwise attained. A "recurrent tube" to be attached to a fountain syringe has been devised by Chetwood for the treatment of prostatitis, but serves equally well when the site of the inflammation is in the vesicles.[19] The hot water passes into one arm of the tube and enters the rectum through two small apertures near the distal end. A large opening at the extremity connecting with an outside tube allows of the immediate return of the hot water

from the rectum, and thus a continuous circulation of moist heat about the inflamed area is kept up as long as is deemed needful, generally from ten to fifteen minutes. To insure a continuous flow the end of the tube may occasionally require a little manipulation. About 4 liters of water should be used at one time, kept at a temperature of from 110° to 130° F., to which 1 tablespoonful per liter of water of common salt or citrate of potash should be added. Ichthyol, 4 cc. to the liter, may be used in addition if desired.

This hot-water treatment should at first be employed daily just before going to bed. Later, three times, and still later, once a week, will be sufficient.

Massage of the Seminal Vesicles.—Massage of the seminal vesicles is a still more important therapeutic measure. According to Thomas, appropriate, intelligent and efficient massage is unquestionably the best procedure primarily in the average case, and will suffice to effect cure in the majority. But if the ejaculatory duct is completely stenosed, massage will be futile as a form of treatment. Operation however, should only be considered after massage has failed or availed not.[124]

The object of massage is to strip the vesicle of its infected contents and if possible, to establish and maintain efficient drainage through the presumably more or less occluded excretory duct. The maneuver is most easily carried out with the patient in the genu-pectoral position, but he may stand bent over a table or low-backed chair, his heels separated and the toes turned slightly inward, so as to insure a firm "stand." The operator's finger is inserted into the rectum until it has passed the internal sphincter, where the apex of the vesicle of the side affected should be palpable above the prostate. Firm downward pressure is applied by the end of the finger, the amount of this pressure being carefully regulated however, by the pain it causes and the degree of inflammation discernible by palpation.

After it has been demonstrated that the patient can tolerate the treatment fairly well, Chetwood suggests extending the massage to the upper pole of the vesicle, which is beyond finger's reach, by the use of a rubber masseur which he has designed for the purpose. Such an implement, however, cannot be accurately guided by the sense of touch, no matter how diligently one tries to follow the maxim of Legueu. A better plan is that of bimanual massage, which has been thus described:[102]

As the finger within the rectum moves laterally and upward, the other hand should be placed upon the abdomen so that its fingers appose the rectal finger. The vesicle can be recognized by the peculiar feeling it imparts to the apposing fingers as it slips back and forth between them. Both hands have a part in the compression and massage of the vesicle which lies thus between them. Any hard nodular areas, which may be diverticula from the main channel of the vesicle, or infiltrated areas, are massaged and compressed by a lateral motion,

and the contents are mobilized and perivesicular edema and infiltration improved. This compression is continued as the apposing fingers follow the vesicle from its upper pole toward its apex, whence it is compressed between the abdominal fingers, the pubis, the prostate and the rectal finger.

This procedure is not so easy of accomplishment as the single-finger method, but its results are worthy of some pains in acquiring the skill necessary for its successful application.

Diathermy.—Diathermy by means of the electric current may also be useful in inflammation of the vesicles, although many urologists are inclined to look upon its use as a maneuver for psychic rather than physical effect, and to discredit it accordingly. But it is not unreasonable to assume that measures similar to those approved in the treatment of orchitis and epididymitis might be equally efficient if properly administered in selected cases of seminal vesiculitis.

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CHAPTER VIII.

THE MALE URETHRA.

ANATOMY AND EMBRYOLOGY OF THE MALE URETHRA.

Embryology of the Urethra.—In considering the embryology of the penis we have already described (page 122) how the lengthening of the uro-genital sinus from which the external genitalia originate, gives rise to the major portion of the penile urethra, and also, how the remainder of the urethra is formed by closure of the primitive uro-genital opening, while the meatus at the tip of the glans penis comes into existence subsequent to the opening out of a groove in the solid urethral plate.

Special study of this process of closure[27] has shown that while the female embryo in its second and third months has an imperforate glans clitoridis, in the male the glans has been tunnelled by the epidermis at the apex passing in and back, thus forming a solid plug which by central desquamation eventually produces a lumen. The deep layer of epidermal cells on the surface of the glans will be seen to be continuous with those of the same layer in the urethra, and "nests" of such cells often fill the canal. This tunnelling process continues through the tissue which in the female will eventually produce the vestibule; in the male, an orifice remains open behind the frenum and somewhat anterior to it.

The epidermis continues to proliferate both on the surface and below, the deeper layer, as the cells multiply, gradually effecting closure of the opening. Thus the epidermal layer does three things in closing the urethra below: (1) It proliferates in at the apertures solidly, carrying the superficial cells in its center; (2) the deeper contiguous active cells unite to close any aperture; and (3) the superficial epidermis proliferates over the closed apertures so as to make a surface. Finally, the central cells in the blocked urethra break down and form the lumen. Hypospadias, in its varying degrees, results from the failure of this closure.

Other investigators do not attach quite so much importance to the part played by the epithelium. According to another view[60] the process which results in the closure of the genital groove is a mesoblastic activity spreading along the penis, affecting especially the lips of the genital groove, being, in this investigator's opinion, a direct extension of the process which results in the formation and union of the lateral fold in the entodermal cloaca. The two small projections upon the caudal boundary of that transverse slit which represents

the opening of the common cloaca, termed *Analhoecker* by Reichel, who was the first to describe them, gradually curve forward and meet at the mid-line, and following this the lips of the uro-genital opening immediately in front are drawn together and united. From this point forward to the base of the glans, a similar activity prevails; the lips of the genital groove elongate, thicken, converge and ultimately unite in the mid-line to form the floor of the spongy urethra. The activity spreads rapidly along the penis until the groove is converted into one continuous tube lined by epithelium from bladder to base of glans. The deeper portion of the epithelial plate or core undergoes no change for a considerable period following closure of the genital groove. It probably develops later in conjunction with the glands of the urethra and the mucosa which forms its lining.

Development of the Urethra Within the Glans.—During the third month of fetal life the glans and corona are gradually encroached upon by a mass of vertical epithelial cells continuous with the mass of cell-elements from which the "spongy urethra" has already been formed. At the base of the penis, however, this cell-mass goes deeper, extending backward into the tissues of the penis itself. At the same time proliferation of the surface epithelium is going briskly forward, and upon the inferior surface a deep furrow develops which eventually extends into the mass of epithelial cells which has formed a "core" in the glans and gouged out a groove along its edge. Near the apex of the glans this furrow is not very deep, but as the corona is attained it descends further, deepening until it becomes continuous with that other groove already formed in the tissues of the penis proper.

The frenum is formed as a bilateral structure from the lips of the sulcus in the glans during the development of the prepuce.[60] Closure of the genital groove brings the two parts of the frenum together, and a floor for the urethra is thus completed.

Development of the Verumontanum.—Development of the verumontanum from Müeller's tubercle, which is a rounded elevation lying on the mid-ventral floor of the uro-genital sinus, takes place about the fourteenth week of intra-uterine life. The venumontanum at this period is indicated only by this rounded elevation on the floor of the prostatic urethra, the presence of which is due to the upward growth of the ejaculatory ducts. Here also will be found a closed sac-like cavity which is to be the prostatic utricle.

Formation of the Tubules.—From recent investigations[74] we learn that definite glandular tubules communicating with the posterior urethra appear at the periphery of the verumontanum about the fourteenth week of fetal life. These tubules have their origin in the invaginations of the mucous covering. Two weeks later a second group of tubules has appeared. These take their rise in the suburethral portion of the middle lobe of the prostate. They lie just below the outer stratum of the tubules previously formed, and communicate with the urethra about the middle third of the verumontanum. The

upward slanting course of the ejaculatory ducts is apparently a factor of considerable importance in pushing these tubules upward toward the collicular prominence.

Tubules originating in the utricle appear about the twenty-fifth week. They are found largely in the anterior portion of the utricle, their starting-point being an invagination of the wall of the prostatic urethra.

These three sets of tubules can be plainly identified by the thirty-first week, and by this time the prostatic utricle will be found in communication with the posterior urethra, the opening being situated at the summit of the verumontanum. A well-developed stroma is now discernible between the tubules, similar to that found in the prostate, which encloses and supports all the glandular elements of the colliculus seminalis. Thus at birth the tubules originating in the mucous membrane are found in the upper third near the internal sphincter of the bladder, lying parallel to the urethral floor with their blind ends pointing backward toward the bladder, and all opening through the sides or top of the venumontanum into the prostatic urethra.

The tubules arising in the prostatic region occupy the middle third of the organ, their blind ends well within the deeper tissue, but lying in an upward and outward direction, so that their orifices open along the sides of the verumontanum, or occasionally, in front of those of the utricle or ejaculatory ducts.

The third group of tubules arising from the periphery will be found at birth practically parallel to the floor of the urethra, their blind ends toward the internal vesical sphincter and their termination in an orifice communicating with the cavity of the prostatic utricle.

Anatomy of the Male Urethra.—The urethra is a canal having one termination in the urinary bladder and the other at the exterior of the body, its function being the conveyance of urine, and in the male, the secretions from the prostate, testicles, seminal vesicles, Cowper's glands and the secreting glands of the urethra itself, which, in combination, form the spermatic fluid.

The Prostatic Urethra.—Beginning at the interior orifice, the urethra lies at first in the prostate, which is fixed at the base by the vesical layer of the pelvic fascia, forming the superior layer of the triangular ligament. To this ligament the urethra is intimately connected, passing through it about 1 inch behind the symphysis pubis.[31] Embryologically, the prostatic urethra extends only from the vesical orifice to the point where the canal is entered by the lowest of the prostatic tubules, but arbitrarily the term serves to indicate that section of the urethral canal between the bladder outlet and the deep layer of the triangular ligament.[56] The prostatic urethra passes from the base to the apex of the prostate, lying a little back of the median line. At first its course is almost vertical, but lower down it makes a forward turn and emerges from the prostate just in front of the apex.[72] The

forward projection of the verumontanum makes the urethra appear to have a crescentic outline when viewed in a cross-section taken from the prostate, but if the urethral canal be incised from in front, the verumontanum will appear as a ridge extending its entire length. The orifices of the ejaculatory ducts and of the utricle will be in evidence surrounding a slight tumefaction visible near the middle of this ridge. Below this point the verumontanum becomes a crest, very distinctly visible, but above it broadens out to receive the ducts of the third prostatic lobe.

The Verumontanum.—The verumontanum is a small, rounded, oval, elliptical or conical elevation, situated on the floor of the proximal half of the posterior urethra. It is normally of a pale pink color, of a shade so much lighter than the surrounding mucosa, as to be readily observable through the urethroscope. The floor of the urethra and the suburethral group of glands (gland acini) separate it from the prostate.[56] The verumontanum is formed, as we have already seen, by the ingrowth of the Wolffian and Müllerian ducts. Though its shape and dimensions vary widely in different parts, most commonly the upper end rises abruptly from the floor of the urethra, its greatest height and width being at the point where the ejaculatory ducts and utricle open into the urethra, which is usually about 0.3 cm. below its upper end. Forward from this point the structure ordinarily tapers off gradually until its fibers are distributed among those of the urethral floor, and at its lower end it spreads out until it is no longer distinguishable, being merged into bands of tissue, numbering anywhere from one to five, some of which may attach themselves to the lateral walls of the urethra.

The Sinus Pocularis.—The sinus pocularis usually has its mouth on the anterior surface of the verumontanum, about the mid-line, although it occasionally appears on the superior surface. It is most commonly round, but may be slit-like or quarter-moon in shape. Its length is about $\frac{1}{8}$ inch. This sinus is an encapsulated glandular organ, the acini of which open by smaller and larger ducts into a common duct; this common duct in turn, usually opening on the anterior surface of the verumontanum. An interglandular stroma arises in the sinus wall and forms a part of it, this stroma serving to separate the glandular acini. There is often considerable variation in these glands, some being at times simple and racemose, while again they will exhibit a distinct intra-acinious proliferation. The wall or base of the acini is composed of a flattened layer of connective tissue cells, upon which are immediately apposed the cells of the acini themselves. The latter may be simple columnar or simple cuboidal in type, more often the latter. Occasionally, the cells of the acini are so closely packed that they appear somewhat squamous in type. The number of cell layers is usually two or three, although at times, owing to the way the specimen has been sectioned, it will appear manylayered. The nuclei are small-sized, rather round in shape, and

usually take the stain well. The protoplasm is clear and also takes the eosin stain with avidity. The lumen of the glands seems empty, but occasionally corpora amylacea are seen in them. The common duct usually pursues an oblique course through the sinus pocularis and is lined by the same type of epithelium as the acini. The entire sinus is enclosed in a very firm capsule which the microscope shows to be made up of fibrous tissue mixed with a good proportion of smooth muscle fibers.[56] We have found no traces of elastic tissue in the verumontanum, but Rytina claims that by means of special staining he was able to demonstrate its presence.

The Membranous Urethra.—The membranous urethra is the name given to the section which passes downward and forward between the two striæ of the triangular ligament, and extends from the apex of the prostate to the upper surface of the bulb of the corpus spongiosum. Though less than ½ inch in length, it is nevertheless an important part of the structure in that, if we except the meatus, no other section of the urethra is so firmly fixed and difficult to dilate. This is because it is surrounded by the compressor urethræ muscles, which lie between the two layers of the ligament at this point. Cowper's glands are situated close behind this section of the urethra, although their ducts open upon the floor of the fossa bulbi. The walls of the membranous urethra are made up of non-striated muscle fibers which are continuous with the muscle fibers of the prostate.

The Spongy Urethra.—The spongy urethra as its name implies, lies within the corpus spongiosum of the penis. It comprises that portion of the urethra which extends from the triangular ligament to the external meatus, passing through the erectile tissue of the bulb as well as the corpus spongiosum and the glans. Reference is habitually made to a *bulbous portion* of the spongy urethra, and to the *fossa navicularis,* which indicates that section lying within the glans penis. The proximal part of this section has a forward and slightly upward inclination, but the distal part, being freely movable, follows the curve of the penis as it hangs downward. At the point about ½ inch from the posterior extremity of the bulb where the urethral canal enters the corpus spongiosum, the layer of erectile tissue is very much thinner on the anterior surface than it is on the postero-inferior aspect, but as it progresses it lies more nearly in the center of the spongy tissue. In the roof of the spongy urethra a number of small indentations can be made out, the mouths of which turn toward the external meatus. These are called *lacunæ urethrales,* and one of them, lying in the roof of the fossa navicularis, is of quite large size.[31]

The External Meatus.—The external meatus appears as a vertical slit at the apex of the glans penis. It is the least dilatable and most constricted part of the entire urethral canal; hence, an instrument which will pass the external meatus will pass through a normal urethra.

Structure of the Urethra.—Structurally the urethra of the male is composed of mucous membrane with a plentiful venous system. In

its upper part, that is, the prostatic and membranous portions, involuntary muscle is found, but this muscular layer disappears after the spongy portion begins, so that no part of it is visible after the bulbous urethra has been passed. There are two layers of muscle fibers, an outer circular layer, showing especial development at the internal urethral orifice, and an inner longitudinal layer.

The Epithelium.—The epithelium of the urethral mucosa resembles that of the bladder in the upper section of the prostatic urethra, being transitional in character; but in the lower prostatic urethra, and in the membranous and spongy portions as far down as the fossa navicularis, the structure of the epithelium becomes columnar. In the fossa navicularis itself we find a lining of stratified squamous epithelium.

Length of the Posterior Urethra.—Surgically at least, the length of the urethra is a matter of considerable interest, and one upon which there is a rather wide divergence of opinion. It would appear from the authors' investigations that as the individual grows older there is a gradual increase in the distance from the vesical orifice to the upper margin of the verumontanum. Up to the fifth year this measurement averages 0.55 cm. During the second decade the length of this portion of the posterior urethra is increased to 1.2 cm., and from that age on there is a slow gradual increase in its measurement. Apparently the length of the upper end of the posterior urethra tends to grow greater as life advances, so that in old age the average measurement from the beginning of the urethra to the upper end of the verumontanum is 1.85 cm.

Length of the Anterior Urethra.—The variations in the length of the anterior urethra as compared with the penile length, were studied by Reynolds[53] and as a result of this investigation he gives the average measurements as

Penile length	2.78 inches.
Anterior urethra	5.50 "
With bladder empty	7.61 "
With bladder full	7.51 "

His oldest patient was aged seventy-five years, and his measurements were: Penile length, 3.5 inches; anterior urethral length, 6.75 inches; length with full bladder, 9.25 inches. In a boy, aged eighteen years, the measurements were: Penis, 2.5; anterior urethra, 5; with empty bladder, 7.5. The full bladder measurement was not taken.

Most of the measurements given in text-books are compiled from postmortem records, so that these figures, though based on a small number of examinations, are of value because they were obtained from living and relatively normal subjects.

ANOMALIES OF THE URETHRA.

The most frequently recurring anomalies of the urethra are those comprised in the conditions knows as *hypospadias* and *epispadias*,

and the various forms of *hermaphrodism*, all of which have been discussed in preceding chapters. (See pp. 129, 133, and 215.)

Urethral Duplication.—It is asserted by Keyes that true "double urethra does not exist, except with double penis." A large number of observations have been collected, however, where more or less complete duplication of the male urethra has been authentically reported, involving the canal from the bulb to the meatus, and accessory canals have also been described which were equal in size to the normal urethra and communicated freely with it in the bulb.[1] The most recently reported case of this kind which we have been able to find is that of Bernadet[4] published in 1923. A man, aged thirty-two years, presented himself for treatment of a chronic gonorrhea complicated by stricture and prostatitis. Examination revealed a second meatus directly above the normal one, but otherwise the penis showed nothing unusual in shape or appearance. The patient stated that he had always urinated from both meati and had never suffered any inconvenience from his anatomical peculiarity. Exploration and urethroscopy showed that the supernumerary urethra bifurcated from the normal one at the anterior extremity of the bulb, a single normal channel conveying the urine from the vesical orifice to this point. An interesting observation was that the anomalous urethra though somewhat diseased had not suffered as severely from the gonococcic infection as had the normal one.

Certain forms of urethral duplication have been classed as epispadias, as for example, that reported by Lebrun,[36] whose patient came for treatment of an anomalous meatus situated below the symphysis pubis at the root of the penis. From this opening to the normal meatus, which occupied its proper position at the apex of the glans, extended a deep sulcus. A No. 14 catheter inserted into the anomalous orifice passed without difficulty through a canal which gave access to the bladder, but on endeavoring to penetrate the normal urethra it was found impossible to use any instrument larger than a No. 16 bougie-a-boule, and the passage of this demonstrated the existence of a stricture 10 cm. from the normal meatus. By resecting the bladder opening of the abnormal canal, it was successfully closed, and the patient relieved of the urinary incontinence which had persisted during the entire twenty years he had lived.

An individual whose condition was described by Aievoli[1] had two meati, the supernumerary one opening just above and a trifle posterior to the normal one. From the abnormal orifice a canal ran backward to a blind cul-de-sac beneath the symphysis pubis. The normal urethra presented no peculiarities either of size or comformation, and it had no communication with the dorsal canal. No urine passed through the supernumerary urethra even when the normal opening was held closed. A number of cases similar to this have been recorded,[11, 18, 38] and the literature on all types of urethral duplication up to 1916, has been thoroughly reviewed by MacKenzie.[42]

Urethral Diverticulum. Allied in many instances to duplication of the urethra are the congenital diverticula which are occasionally reported, though so rarely that Watts in 1906,[76] was able to collect but 16 cases from the literature. The diverticula are pouches or cavities having an opening into the urethra and are usually so situated as to be practically always at least partly filled with urine. Such accessory pouches may also be acquired later in life, but their occurrence under these circumstances can hardly be classed under anomalies in the sense here intended.

FIG. 87 (Osgood's case).—Urethrogram of a diverticulum arising in the bulbous portion of the anterior urethra. When injected, this mass could be easily felt at the upper portion of the scrotum. Pressure emptied it completely.

True Diverticula are those lined with mucous membrane identical with that of the urethra, while *false diverticula* are cavities found in the peri-urethral tissue, the walls of which are neoplastic in character, and would therefore, be of postnatal origin in the majority of cases. Escat[18] has described, together with 2 human cases, a urethral pouch observed in a kid, aged two months, the pouch being transparent and having the appearance of a "little stomach."

Lessing[76] reported a case of congenital perineal diverticulum where, on incision of an inflammatory mass in the perineum it was found to have its origin in a tube the size of a lead pencil and several centimeters

in length, which communicated with the bulbous urethra. The structure of this tube was similar to that of the normal urethra.

Etiology.—The exact cause of urethral diverticula is still obscure, although a vast array of hypotheses have been advanced to account for their formation. Suter[62] believes it due to a congenital defect in the genital sulcus. Histologically he regards it, not as a simple dilatation of the wall of the urethra, but as a pouch arising from the epidermis lining the urethra's lower wall. As the urethra develops from the genital sulcus its canal is gradually hollowed out in the epidermal epithelium. While this process is going on the canal is partially open, and at times "bridges" of epithelium connect it with the external sulcus. The cells forming the epithelial lining of the canal become cylindrical in form, but those forming the bridges remain squamous. As we have seen, the canal under normal conditions closes and finally becomes the fully-formed urethra, but Suter believes that in certain instances these epithelial bridges fail to absorb and persisting, eventually produce diverticula.

The theory advanced by Kaufmann[76] is that congenital urethral diverticula arise from obstruction to urination during fetal life, because of a delayed union of the penile and posterior urethra. The proximal end of the urethra is thus dilated, and when union finally takes place, the dilatation fails to contract, persisting to produce a diverticulum. Watts thinks a good part of the congenital diverticula observed may be accounted for by some kind of urinary constriction during fetal life, such as prenatal strictures, adhesions between the prepuce and the meatus, or contractions of the preputial orifice, or possibly congenital valve formation.[5, 16]

Diagnosis.—A diverticulum is easily recognized by the difficulty in urination which it causes, this being noticeable in most cases very early in life, as well as the formation of a distorting mass upon or near the penis. When not distended with urine the sac will be soft and pliable, but when filled will appear as a firm tense tumor mass, which can usually be decreased in size, if not wholly evacuated, by manual pressure.

Treatment.—The only remedy is surgical excision of the sac, and reconstruction of the urethral wall. This treatment has proved efficient in most of the reported cases.

Congenital Valves of the Urethra.—It has been mentioned that congenital valves of the urethra may be causative factors in the production of diverticula and dilatations in the new-born, but enough instances have not as yet been put on record to offer conclusive proof of such an etiology for *congenital* diverticulum.

Obstruction.—Obstruction due to the presence of abnormal valves in the posterior urethra has been described from time to time as an extremely rare anomaly, but although few cases have been reported, the condition probably occurs more frequently than this scarcity of reports would seem to indicate. The subject has been exhaustively

studied by Englisch[17] who differentiates between obstructions which exist in embryonic life but disappear postnatally; and those congenital obstructions which persist permanently after birth. Examples of this first type are atresia of the meatus both internal and external, or of the openings of the utricle, or of Cowper's glands. All valve formation and stenoses of the urethra are of the second type, the site of predilection of congenital valves being the prostatic urethra above and below the verumontanum, less frequently at the external meatus or even in the prepuce. Stenoses are most likely to be located at the junction of the bulb and the membranous urethra, or in the posterior termination of the fossa navicularis; less frequently, in the external urethral opening.

In most of the cases which we have reviewed the anomalous formation was at the anterior end of the verumontanum. Here folds or ridges are normally found in the mucous lining of the urethra, and under healthy conditions the crista urethralis is divided into two ridges which "becoming less and less prominent, gradually fade out in the posterior wall of the bulbous urethra."

Etiology.—The etiology of this anomaly is still far from clear, and there is enough variety in the different types which have been available for study to make no one explanation capable of accounting for all cases reported. In 1913, the senior author had the opportunity of investigating this condition in an infant aged three and a half months, autopsy upon whom showed that the tissues of the verumontanum, though disposed in the usual way (see page 306), instead of disappearing by spreading out on the floor, continued down to the membranous urethra, where it divided into two portions and attached itself intimately to the entire urethral circumference, with the exception of a very small slit-like opening on the floor of the urethra, just to the left of the median line. This orifice was lined with mucous membrane and permitted the entrance of a fine probe. This unusual arrangement caused almost complete obstruction to the urinary outflow, and below the point of blocking, the bulbous urethra was considerably dilated.

In our opinion this was due rather to an anomaly of the Wolffian and Müllerian ducts, than to any defect in the urethra itself. To recapitulate what has already been said in discussing the embryology of the urethra: These structures, which in the male become the ejaculatory ducts and the prostatic utricle, enter near the base of the prostate and pass through that gland in an oblique direction until they approach the urethra, when they turn, and for a short distance, run parallel with the axis of the urethra, finally finding a point of entrance into its lumen. During the passage of these ducts through the prostate, their musculature is bound together by a very firm and well-defined sheath of connective tissue. On their approach to the urethra they push up the floor of that structure into a mound, thus forming the verumontanum, but they still remain separate from all surrounding struc-

tures, their tissues being superimposed upon those of the urethra. Ordinarily, immediately below the openings of the ejaculatory ducts and utricle, the tissues surrounding them become distributed among the fibers on the floor of the urethra, finally disappearing altogether.

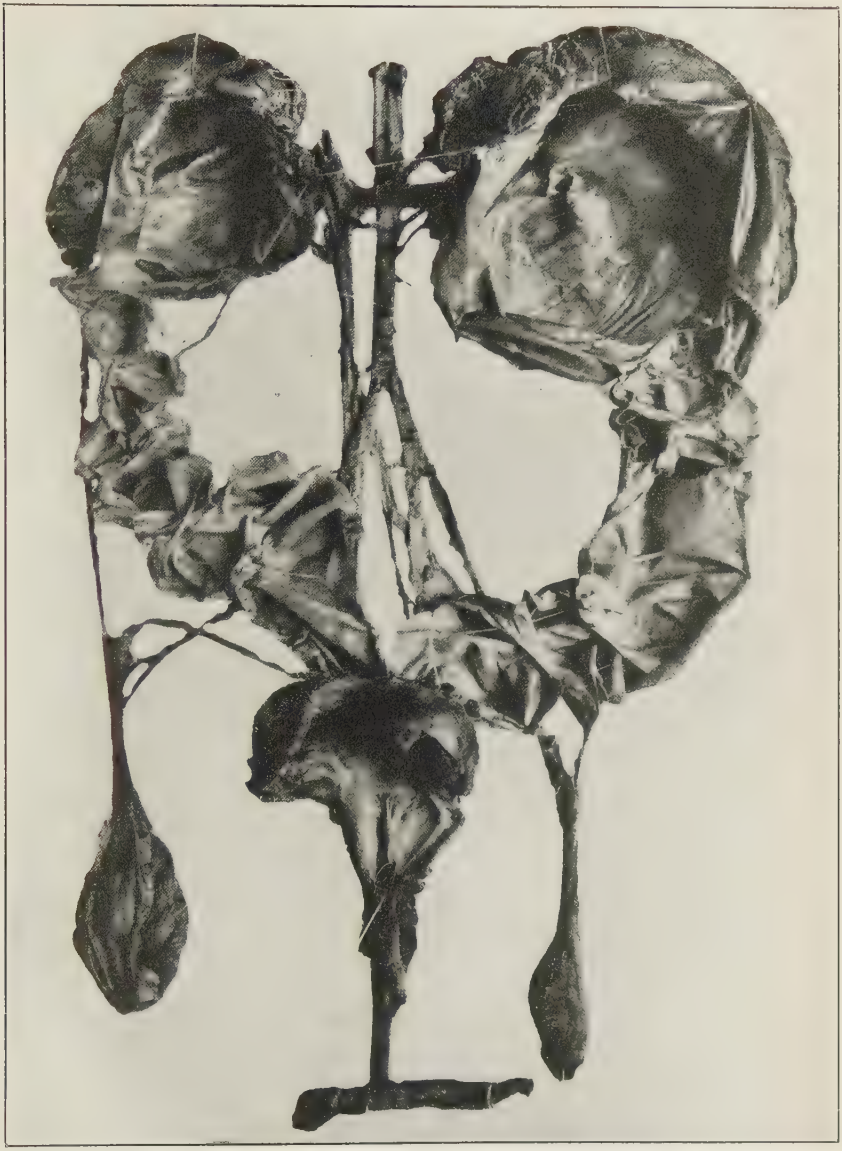


FIG. 88 (Lowsley's case).—Congenital malformation of the posterior urethra. Stilette inserted into aperture through the diaphragm-like obstruction of the posterior urethra which occurred at the lowermost portion of the veru montanum. The ureters and kidneys on both sides are laid open and show marked dilatation.

A case similar to ours was published by Knox and Sprunt in 1912.[33] They considered it simply a progressive malformation and not an instance of arrested development. Their patient, however, attained the age of five years before succumbing to the effects of the retention

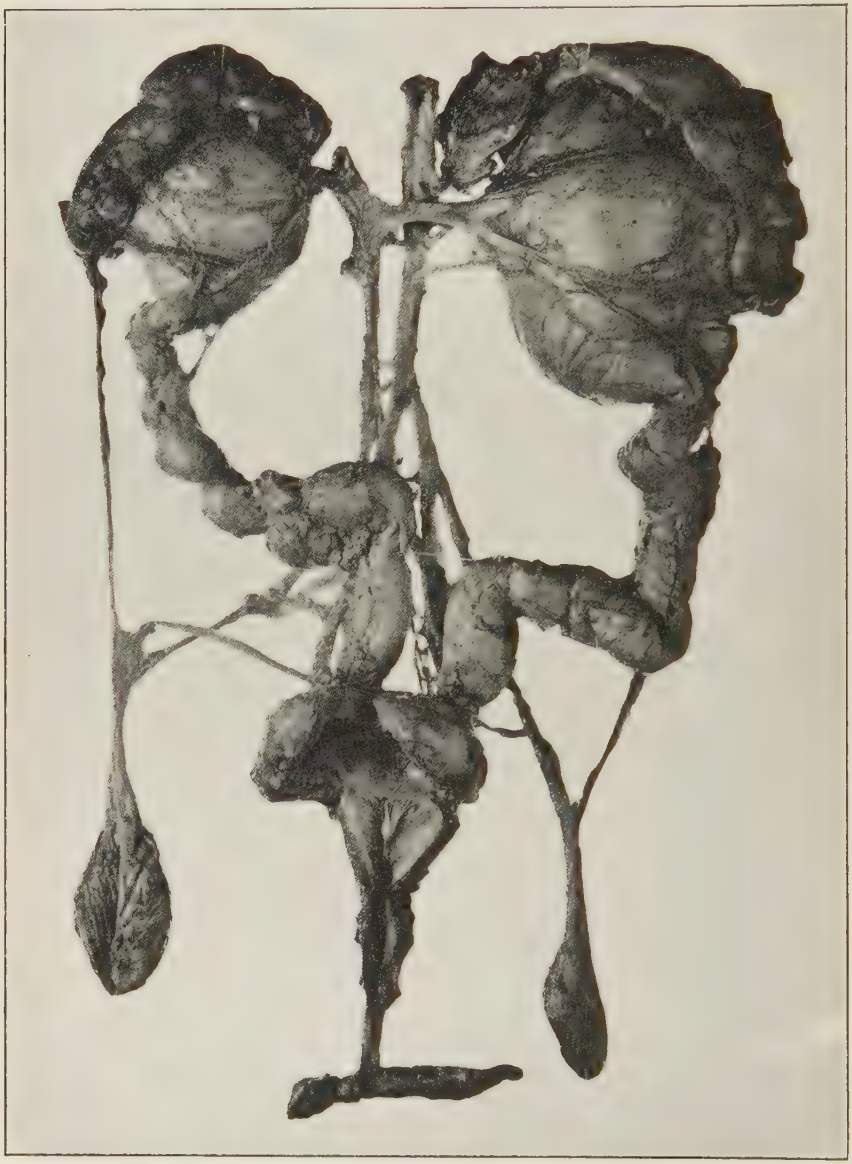


FIG. 89 (Lowsley's case).—Congenital malformation of posterior urethra (front view). Ureters markedly dilated and distorted. Kidney pelvis greatly enlarged, particularly on the left side.

and dilatation which the obstruction induces. Most of these anomalies come under observation in infancy and early childhood. In the 36 cases collected by Young, Frontz and Baldwin[79] in 1919, 12 patients were less than one year old; 9 between one and five years; and 4 from

FIG. 90 (Lowsley's case).—Congenital malformation of posterior urethra (back view) showing abnormality of the blood supply. Three arteries pass to the left kidney and two to the right.

five to ten years. Thus 25 were below the age of ten years, as compared to 9 above that age. The youngest instance was in a five-months' fetus, and the oldest Iverson's patient who was aged eighty-five years.

Some years after the publication of the senior author's case, Watson[75] suggested that the anomalous attachment of the fibers of the inferior striæ about the entire circumference of the urethra which was there noted, should "focus our attention more on the lower margin of the colliculus than on the Wolffian ducts or sinus pocularis." This investigator has concluded that "the valve formation is due to the growth and attachment of the tip of the colliculus to the roof of the urethra, and occurs at the time of marked epithelial activity of this and associated parts, namely the invagination of the veru mucosa to form the first observed true tubules of the verumontanum." He feels therefore, that the explanation offered by the author is not adequate for all cases.

Types of Congenital Obstruction.—The idea that no single etiological theory can include all cases of congenital valve formation in the posterior urethra has been much further elaborated by Young and his co-workers, who, basing their opinion upon a careful review of 22 cases gathered from the literature, and 9 personal observations, differentiate three types:

Type 1 is represented by Knox and Sprunt's case and that of the senior author. Here there is a ridge lying on the floor of the urethra, continuous with the verumontanum, which takes an anterior course and divides into two fork-like processes in the region of the bulbomembranous junction; these processes being continued as thin membranous sheets directed upward and forward. They may be attached to the entire circumference of the urethra, or there may be a slight separation of the folds anteriorly.

Type 2 shows a more or less cylindrical ridge like that of Type 1, save that it passes from the upper surface of the verumontanum toward the internal sphincter where it divides into two fork-like processes which continue as membranous sheets attached to the urethra just outside the internal sphincter, as in Type 1.

Type 3 shows the obstruction attached to the entire circumference of the urethra, with only a small central orifice. This was called by Jarjavay an "iris valve" because of its likeness to the shape of the iris of the eye. The most frequently described variation of this type is "a more or less crescentic or semicircular fold crossing the urethra and being attached either to the roof or floor."

Of the 26 cases considered by these authors, 16 fell into the first class and 9 into the third, the second class being represented by but a single case of their own.

A very interesting feature of these congenital obstructions is the arrangement of the folds which frequently offer little or no impediment to the passage of instruments or fluids from without inward, but which greatly reduce the caliber of the urethra during urination.

The concave surfaces of the valves are always directed toward the bladder and are ballooned out by the urinary stream. It can be readily appreciated that this tends to befog the diagnosis, and may in certain measure account for the very few instances where accurate diagnosis has been made during life. Several cases[28 51] have been reported since Young's article appeared, which, thanks to the efforts of earlier workers, were better comprehended at the outset.

INJURIES TO THE URETHRA.

Instrumental Trauma.—Injury to the urethra by too vigorous or otherwise ill-advised instrumentation has already been several times mentioned in the preceding paragraphs. There is no doubt that the unwise use of instruments in inflamed or otherwise hypersusceptible urethræ is responsible for many strictures, and no doubt also for not a few periurethral abscesses or even fistulæ.

False Passage.—False passage means simply that the user of the urethral instrument has passed it into the tissues of the wall instead of into the bladder as was his intention. The beak of the instrument will usually be found to have entered the wall at the apex of the prostate, or sometimes between its lateral aspect and the rectum. Free bleeding following the withdrawal of the instrument will demonstrate the nature of the injury, even if it has not been determined by rectal palpation.

Burns.—Burns of the urethra, usually by chemical agents, have occasionally been recorded. Following such an accident the entire mucosa of the anterior urethra is likely to slough off,[49] and the subsequent cicatrization of the interior of the canal results in a most severe stricture. Deteriorated argyrol solutions, lunar caustic, carbolic acid, or a too-strong solution of bichloride of mercury, have all been known to produce this effect.

Rupture.—Rupture of the urethra is the most common traumatic accident. Direct violence, such as that sustained by falling astride some hard object is likely to cause a rupture in the bulb, while that of the posterior urethra is more often observed in connection with fracture of the pelvis, or a strain or dislocation in that area. Only the membranous portion of the urethra is subject to rupture, the prostatic portion usually escaping damage in all but the most extensive crushing injuries. Rupture occurring in the bulb is usually due to impaction of the urethra against the superimposed pubic arch.[24] A boy, aged eight years, seen by A. R. Thompson[66] "fell from a pillar upon the pavement below with both his limbs strongly abducted, in such a way as to nip his penis between the pavement and the first part of the symphysis pubis. The penile urethra was ruptured from $2\frac{1}{2}$ to 3 inches from the meatus, that is, about the same distance in front of the membranous portion."

Such ruptures seldom receive adequate treatment, especially when

the victim is a child, as is frequently the case. As Thompson very aptly says: "The diagnosis of ruptured urethra must not rest upon a

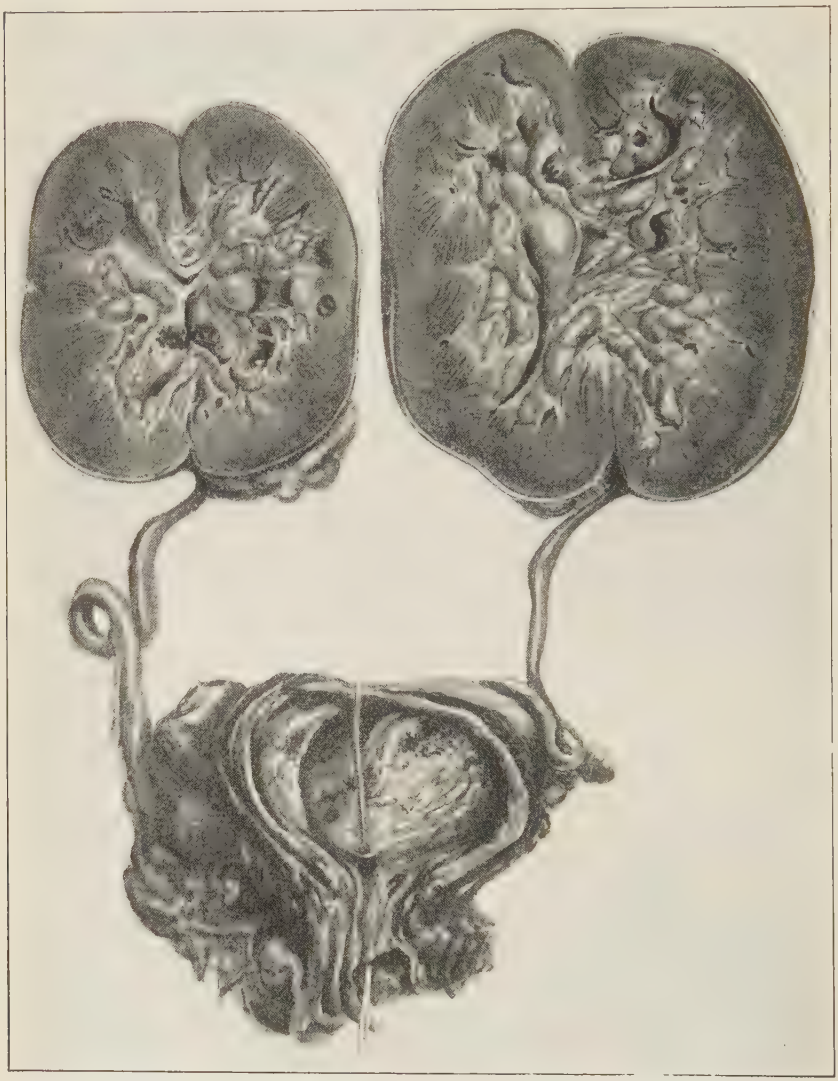


FIG. 91.—False passage through prostatic urethra. Its course is shown by the probe which passes through it. Its outer opening is near the apex of the prostate and extends to a point near the middle of the trigonum vesicæ. This lesion caused death in this case, septicemia and uræmia following the traumatism. Suprapubic drainage upon admission to the hospital, twenty-four hours after injury, failed to save the patient's life.

hope that nothing serious has happened. The history of the accident, which can usually be supplied quite adequately by the patient, should

point to the correct diagnosis, and it is never safe with the history of a fall upon the perineum to neglect the probability of a rupture of the urethra."

Diagnosis.—The diagnosis can usually be made without much difficulty. Pain in the perineal region will be experienced, often radiating toward the meatus, and if the bladder has had time to become much distended, there will be abdominal pain as well. Inspection will show ecchymosis, often widely extended, blood will trickle from the

FIG. 92.—Rupture of the urethra with extravasation. The resulting inflammation has caused great distortion of the scrotum and penis. The inflammatory process extends to the suprapubic region and anterior abdominal wall if operative intervention is delayed.

meatus, while a sizable hematoma will be apparent in the perineal region. Except in rare instances, there will be absolute inability to void the urine, and extravasation will very soon begin. If the rupture lies at the junction of the bulbous and membranous portions, the urine enters the superficial intra-aponeurotic perineal space, passes first into the scrotal tissues and then over the body of the pubis between the spine of the pubis and the symphysis, reaching the abdominal wall by way of the scrotal abdominal passage.[24] If there is a tear in the membranous urethra, the urine will find its way between the layers of the

triangular ligament. The infection and sepsis certain to follow if the extravasation of urine is not promptly checked, may quickly bring about a serious or even fatal result.

If the symptoms point to a urethral rupture, no attempt at catheterization should be made, for if the tube is not completely severed the chances of healing without stricture are very much better, and the passage of any instrument will jeopardize what small remnant of tissue may still be intact. In any event it can only increase the damage already sustained and induce further hemorrhage.

Treatment. The most rational treatment is immediate incision of the hematoma in the perineum so that the blood clots may be evacuated and hemostasis of all bleeding vessels established. If complete division of the urethra is revealed, a sound passed through the meatus will show the location of the distal end. To find the proximal end is not so easy. One plan is to dry the operative field and to have gentle pressure made by an assistant upon the bladder until a little trickle of urine draws the operator's eyes to the right spot. If this plan fails it is wiser to make a suprapubic incision through which the bladder may be drained, and, if the patient is in sufficiently good condition, retrograde catheterization may be carried out. A sound passed through the vesical orifice of the urethra will demonstrate the location of the proximal end, so that the severed urethra can be united by sutures and the operated area relieved from the dangers of bladder evacuation until healing has taken place.[2] Every effort should be exerted to avoid the infliction of any further injury to the damaged tissue, for the likelihood of stricture is only too great without it.

Gunshot Wounds.—Gunshot wounds of the urethra have[10] already been discussed in connection with war wounds of the penis (page 138).

DISEASES OF THE MALE URETHRA.

Gonorrhea.—**History.**—Gonorrhea is apparently one of the most ancient of venereal affections, as descriptions and references too characteristic to be misunderstood appear in the oldest medical records we possess, such as the Egyptian papyri, the ancient Japanese writings and the Scriptures of the Jewish patriarchs. Hippocrates described an affection which was undoubtedly gonorrhea, and similar references appear in the works of Alexander of Tralles, written in the sixth century of our era.

Modern conceptions of the disease, however, date only from the year 1719, when Morgagni produced a classic work upon the complications of gonorrhea, but it was not until more than a century had passed (1838) that Ricord demonstrated the difference between this disease and syphilis, a confusion which existed for a long period previous to that time. Ricord, however, despite his extensive investigations and really thorough apprehension of the nature of gonorrhea, stoutly maintained that it was not infectious, being

simply a catarrh of the urethral mucous membrane due to the introduction of irritants, which might be of many different origins. But the spirit of investigation was by this time, too strong to be restrained by the pronouncements of any one man, and other workers soon demonstrated beyond a doubt that inoculation of the urethra with gonorrheal pus was regularly followed by a characteristic urethritis. Forty years passed however, before Neisser, following the bacteriological methods instituted by Weigert and Robert Koch, was able to isolate the specific organism, showing by staining the invariable presence of a characteristic diplococcus in the urethral secretions. In a second publication three years later, Neisser demonstrated the morphological characteristic of the organism which now bears his name, as well as its mode of division and its ordinary appearance as it lies within the pus cell. It remained however, for Bumm in 1885, to grow pure cultures of the gonococcus and by the inoculation of the human urethra with the organism thus obtained to produce the full proof of its etiological importance in the production of gonorrhea.

Bacteriology.—Some ten years ago C. C. Warden[73] published the result of a series of investigations wherein he put forward the theory that a certain proportion of the cocci found in the discharges of acute gonorrhea which are coffee-bean shaped and negative to Gram's stain, are actually a variety of staphylococcus, and that gonorrhea may in reality be a double or symbiotic infection due to both gonococci and staphylococci. Wardens's conclusions were very shortly assailed by Crabtree[12] who presented a careful analysis of his methods and results, reaching the final conclusion that "the evidence as presented by Warden that gonorrheal urethritis is due to the staphylococcus albus is based on erroneous interpretation of his observations, and is fallacious." Lumb[40] more recently found that he experienced great difficulty in obtaining cultures from cases of acute gonorrhea, even under the most favorable conditions and with the most suitable media, and this led him to infer that if the organisms with which he was working had been staphylococci and not gonococci "a rapid growth would be expected in many instances" because of the ease with which staphylococci can regularly be cultivated. Yet no less an authority than Koll[34] has asserted his belief in the validity of Warden's findings, and it is not unusual to find the question of the staphylococcus as a causative factor in gonorrhea still under discussion in certain quarters.

Acute Gonorrhea.—Acute gonorrhea may then be defined as an inflammation of the urethra induced by infection with the gonococcus or diplococcus of Neisser. The infection is usually contracted during sexual intercourse, its most common manifestation being an acute infectious suppurative process attacking the mucosa of the urethra and its associated glandular structures.[21]

Period of Incubation.—When the gonococcus has been implanted in the fossa navicularis it will be apparently quiescent for a period varying from two to seven days. It was demonstrated by Finger and

some other Teutonic workers that the epithelium is not penetrated as soon as the columnar cells, which are entered in some cases as early as the forty-third hour after inoculation. But although the infected individual is unaware of it, the organisms begin at once to multiply, so that by the time the disease becomes manifest, they are present in great multitudes, capable of elaborating toxins which institute inflammation of the tissues by their irritant action. The result of this inflammatory process is the outpouring of a watery discharge which, exuding from the urethra, first directs the patient's attention to his condition. The inflamed mucous membrane of the urethra quickly becomes sensitive to the passage of urine, so that micturition is shortly painful, and the discharge is thicker and of a yellowish color. Occasionally the initial discharge may be so slight that the infected person does not notice it until some exacerbating cause, such as severe and prolonged physical exercise, the ingestion of alcohol or excessive sexual intercourse, serves to "light it up." Thus frequently the time elapsing between exposure and the appearance of active evidence of disease may seem to be much longer than the ordinary average period.

If the physician sees a case when the thin watery discharge is still present, the chances of aborting the attack by the immediate institution of remedial measures, are very good, but unfortunately, but few such patients ever present themselves for treatment. Not until an abundant discharge and considerable pain are in evidence does the patient feel himself "sick enough to go to the doctor." But if treatment can be instituted before the organisms have ascended to the posterior urethra, the chances of prompt and early cure are greatly enhanced.

When the patient does present himself, the typical picture of acute gonorrhea will usually be in evidence. According to Kidd[32] it takes from ten to fourteen days for the germs to reach the deep urethra and the prostate, but in 180 cases which he examined, 58 per cent showed that the tubules of the prostate gland and the seminal vesicles had already been penetrated, so that when these structures were palpated by rectum, they felt hot and swollen.

Pathology.—After implantation has taken place on the mucous membrane of the urethral canal the organism first proliferates upon the surface, then spreads by superficial continuity, its endotoxin producing an inflammatory reaction which is characterized by hyperemia, accompanied by serous exudation and quickly followed by an emigration of polymorphonuclear leukocytes from the bloodvessels. The epithelial cells increase in size and loosen, soon being cast off in large quantities. The gonococci are not found within the epithelial cells themselves but are implanted within the interstices between them, thus being able eventually to penetrate as far down as the submucous tissue and urethral glands. As the infection spreads the small capillaries are crowded with leukocytes, which results in phagocytosis and a characteristic purulent discharge. Though the extension of the

infection is along the urethra in the direction of the vesical orifice, it may extend no further than the compressor urethræ, the inflammation being confined to the anterior urethra alone. More often however, the posterior urethra also is involved in the process, and its pathological aspect, under these conditions, is the same as in the anterior portion. Once the organisms have reached this region, they may penetrate the ejaculatory ducts, or later some or all of the numerous openings between the prostatic tubules and sinuses which, as we have already noted (page 305) lie on the distal side of the verumontanum. Should this occur it is likely to lead to complications or even to general systemic infection.

Symptoms.—The active stage of gonorrheal infection is usually well established by the end of the third day. The discharge rapidly becomes thick and purulent and of a creamy yellow color, frequently taking on a greenish cast if the infection is severe. The intense local inflammation is now well marked. The glans is red, tender, turgid and swollen. Its surface sometimes is covered with small shiny ulcers and a certain degree of ectropion is produced by eversion of the red, edematous and often excoriated mucosa at the meatus. The inflammation spreads to the prepuce which in turn becomes swollen, red and edematous, often resulting in a phimosis or paraphimosis. The entire penis is now hot, swollen and tender, the urethra is exquisitely sensitive, and the lymphatics so inflamed that they look like red lines in the tense skin on the back and sides of the penis. If the infection is very acute the inguinal glands on either side may become enlarged and painful, but suppuration rarely occurs.[37] In patients with long prepuces balanitis is likely to develop. The delicacy and great vascularity of the mucosa lining the posterior urethra is evidenced when invasion of this portion of the canal has taken place, by more or less bleeding during the acute stage. The organisms which have reached this region may penetrate the ejaculatory ducts and prostate, producing the clinical picture already described.

Pain.—Scalding pain, the *ardor urinæ* of our forefathers, is nearly always an accompaniment of this stage of the infection, commonly attended by a feeling of weight and vague discomfort in the perineum. This may be present not only during the act of micturition, but practically all the time, often with pain in the lumbar region as well. When the inflammatory process has involved the corpus spongiosum erections often become frequent and very painful, and as the tissues of the urethra have become stiff and inelastic they cannot expand, with the result that the penis assumes a curved position, producing what is known as *chordee*, an intensely painful condition which is likely to result in tearing of the inflamed mucous membrane.

Constitutional Symptoms.—Constitutional symptoms are often surprisingly few, although there may be headache, anorexia and general *malaise*. Constipation is likely to be troublesome and the inflammatory condition induces a desire for frequent evacuations of the

bladder which in the congested state of the urinary canal adds to the patient's discomfort. The usual manifestations of acute illness, however, are almost uniformly absent, and for this reason it is the general experience of physicians that gonorrhea patients are hard to manage, and refuse to recognize the fact that they are suffering from a serious disease fraught with far-reaching and disastrous consequences.

Diagnosis.—*Physical Examination.*—When presented with a probable case of gonorrhea the examiner should first inquire the date of exposure and the time which elapsed between it and the onset of actual symptoms. The patient should be stripped and a thorough examination made, beginning with the retraction of the prepuce to note the amount and character of the discharge. As has been recently emphasized,[65] one cannot too strongly deprecate the habit of not inspecting, or of only cursorily looking at, the infected organ. A thoroughly conducted examination at the first sitting often reveals evidence not only of gonococcal infection, but also of a present or past attack of syphilis, either of which requires energetic treatment. This is especially so in patients who have shown a long incubation period, and in whom the existence of a meatal chancre or a subpreputial sore, with balano-posthitis is a cause of the discharge, is always a possibility.

The epididymes should be palpated and their condition, as well as that of the vasa deferentia, carefully considered. Rectal palpation will offer information concerning the state of the seminal vesicles, Cowper's glands and the prostatic area. Such an examination is especially valuable if there has been previous gonorrheal infection. The skin about the anus, as well as that upon the back and legs, should be inspected, and at the same time any possible enlargement of the inguinal glands would come to notice. The mouth and throat should also be examined, for important evidence of venereal infection is frequently discernible in the oral region.

Examination of the Stained Specimen.—After the prepuce has been cleansed and retracted the lips of the meatus should be gently separated and a sterilized platinum loop inserted to obtain a specimen of the exudate for examination. The specimen is transferred to a clean slide, spread evenly and fixed by passing through a flame. The methods of examination have been already described (page 68 *et seq.*).

In the inspection of the specimen the following points should be taken into consideration: Whether the cells present are mononuclear, or have divided nuclei; whether the organisms visible are bacilli or cocci, in pairs, in chains or in clumps; finally, the relation between the cells and the bacteria. The most characteristic finding is many pus cells which contain no bacteria, few bacteria between the cells, and occasional scattered phagocytes filled with diplococci. Only in a good preparation can the gonococci be identified, and then only after finding a typical phagocyte evenly dotted with diplococci.[69]

Complement-fixation Test.—This test is founded upon the work of Bordet and Gengou (1901) and was first clinically applied by Brück

and Wassermann in 1906, who succeeded in instituting a reliable blood test for the detection of syphilitic infection. Bordet and Gengou found that if an antigen were mixed with fresh immune serum containing the specific antisubstance (amboceptor) and complement, and allowed to stand for a definite period, the complement would entirely vanish. Investigations proved that the disappearance of the complement is due to the fact that the antigen has combined with the amboceptor, thus using up the complement present in the serum. The term "fixation" of the complement was given to this phenomenon, which Dean in 1912 demonstrated to be due to a colloid reaction, inasmuch as the antigen, amboceptor and complement all are colloids. When antigen and amboceptor are brought into contact they unite to form a fine invisible precipitate, and this precipitate "absorbs" the fine colloid particles of complement. The complement is then rendered inactive, and is said to be "fixed" or "deviated."[64]

This test was first used in the diagnosis of gonorrhea by Müller and Oppenheim in 1906.[47] The principal earlier work upon it in this country has been done by Teague and Torry,[64] Schwartz and McNeil,[58] and Thomas and Ivy.[65] Recently in England, David Thomson[69] and others have carried on extensive researches along these lines. Schwartz and McNeil found that the different strains of the gonococcus vary so markedly from one another that antibodies produced in the organism by the toxic products of one strain will not, in many instances bind the complement in the presence of an antigen prepared from another strain. To overcome this they prepared a polyvalent antigen, as "an antigen prepared from many strains fixes the complement whenever one of its component strains does so."

In gonorrheal rheumatism, Thomson found that nearly 100 per cent of the cases gave a definite positive reaction to his technic, "whereas other cases with ordinary rheumatoid arthritis always gives a negative result. This is sufficient to show that the test is a powerful diagnostic agent. The complement-fixation test for gonorrhea, when carried out with careful controls, using a good antigen, and a long fixation method in the ice-chest, is extremely delicate, and compares very favorably with even the Wassermann test in syphilis. With regard to the diagnosis of gonorrhea in women it is invaluable," and serves as an indispensable aid "in cases of rheumatism, salpingitis, ovaritis, etc., and is of the greatest value in all cases, both male and female as a test of cure of the disease."

Cutaneous Reaction.—Endeavors to obtain in gonorrhea a reaction similar to that of von Pirquet as applied to the diagnosis of tuberculosis, have been made from time to time, since Brück in 1909, observed a cutaneous reaction after the injection of gonococcal vaccines in cases of epididymitis. The usual manner of applying the test is to inject a glycerine extract of gonococci beneath the skin by means of a syringe, or to scarify the skin and apply gonococcal protein in powder form to the scarifications. The reports from those who have employed

this test as a diagnostic procedure are so at variance that it still lacks either confirmation or rejection. Cherry and di Palma[6] found it useless in detecting gonorrheal infection in gynecological cases, and the majority of those who have recently made use of it, declare that their results are too uncertain to be of practical value.

Prophylaxis. It is well established that if prophylactic precautions were always taken, infection with gonorrhea would be unusual if not unknown. The methods most approved are: (1) That of irrigation, and (2) that of self-disinfection.

Irrigation.—Irrigation to be effective must be promptly administered, preferably within an hour after exposure, and certainly not longer than three hours, for experiment has demonstrated that the organisms remain upon the surface of the mucous membrane for several hours after being deposited there, and the prompt application of an antiseptic may destroy them if applied before sufficient time has elapsed to permit penetration. The exposed individual first urinates, then cleanses the external genitalia and the surrounding pelvic region with soap and water, and finally applies to the prepuce and shaft of the penis a 1 to 1000 bichloride of mercury solution. The foreskin is retracted, and together with the frenum and coronal sulcus is thoroughly washed with the bichloride solution, while the lips of the meatus are separated and included in the application. When every available surface of the external genitalia has been thus gone over, a container holding an irrigating solution of potassium permanganate is raised not more than 2 feet above the pelvis, and the fluid allowed to flow gently into the urethra through a sterile glass nozzle. After the first few inches of the urethra have been well flushed, the container is raised so as to increase the pressure somewhat, and the remaining portion of the urethra washed out as far as the bulb. About 1000 cc. of fluid, hot as can be borne, should be used. The irrigation completed, the glans and penile shaft should be rubbed over with a 33 per cent calomel ointment, as an additional precaution against venereal infection. The pubic region should be similarly anointed.

Self-disinfection.—Self-disinfection consists in the injection of a 2 per cent solution of protargol into the urethra, followed by anointing with calomel ointment as described above. Urination should always precede the injection. This is the prophylactic measure recommended by the United States Army and Navy.

Treatment.—Few patients come under the physician's supervision until some time after the discharge has appeared, and in most cases there will have been attempts to treat the condition before medical aid was sought. Few persons realize the gravity of the affection, either as a menace to others with whom they may come in contact, or as a cause of serious disability in the future. It is the duty of every physician to impress upon his gonorrhea patient the potential dangers to which he is exposed, and the necessity of guarding from infection those with whom he comes in close relations—his family and associates. The especial menace to the eyes ought always to be emphasized.

All sexual stimulation both physical and mental should be carefully avoided. Highly-spiced foods should be eliminated from the diet, ginger ale and the ubiquitous "hot-dog" being examples of what should especially be avoided. Alcohol in any form must be strictly prohibited. During the first two weeks of the attack exercise must be carefully avoided; rest in bed is the ideal, but it is very seldom the patient can be persuaded to remain there. Horseback-riding or bicycling must be absolutely interdicted, and walking limited to the least amount possible. The testicles must be supported by a well-fitting suspensory, and the medical attendant should personally inspect it when in place, to be sure that it is sufficiently large not to constrict the penis at the peno-scrotal junction, as constriction of the penis at this point may have very serious consequences, preventing proper drainage of the secretions, or even producing stricture later on. Attention should also be given to the manner in which the patient shields his clothing from the secretions. A dressing placed over the meatus and beneath the prepuce will prevent the escape of the discharge and by damming back the pus in the urethra seriously impede the necessary drainage. "Gonorrheal bags" may be easily obtained, which can be so adjusted as to absorb all the discharge upon a piece of cotton soaked in some antiseptic solution, which is placed at the bottom. Strict cleanliness should be inculcated, and the patient instructed to cleanse the prepuce and meatus frequently with cotton swabs which can be immediately destroyed after use, employing hot water and green soap, or other antiseptic.

Hydrotherapy.—Hydrotherapy is an important therapeutic adjunct. The patient should be instructed to drink just as much water as possible; 4 or 5 quarts will be none too much (4 ordinary drinking-glassfuls equals a quart). The irritation and congestion can be greatly relieved by soaking the penis in water as hot as can be borne for half-hour periods three or four times daily, or hyperemia may be induced by allowing hot water to play on the penis, although this second method is usually difficult or impossible for the patient to accomplish by himself at home.

Internal Medication.—Internal medication is of little value. Sandalwood oil, once looked upon as highly efficacious, may still have some efficiency in extremely acute cases, apparently having a soothing action upon the intensely congested mucous membrane. Urinary antiseptics such as urotropine, are highly regarded by some authorities, but many others have abandoned them altogether, some even going so far as to declare that the use of any drug internally is now wholly obsolete. It may be necessary to control the "burning sensation" in the urethra on micturition by giving something to reduce the acidity of the urine, and if painful erection occurs frequently, it may be relieved by the administration of bromides and the use of an ice-bag or other cold application. If the condition is sufficiently acute to cause loss of sleep, suppositories of opium and belladonna may prove

of service. It is important to keep the bowel excreting freely for constipation induces congestion in the pelvic veins which is very deleterious and may favor the extension of the infected area to the posterior urethra, prostate, epididymis and seminal vesicles. It is well to begin treatment by the administration of a reasonably strong cathartic, and inquiry as to the state of the bowels should never be omitted from the future surveys of the patient's general state.

Local Treatment.—The object of local treatment is to destroy the infecting organisms as soon as possible, thus aborting or shortening the course of the infection. We have not, however, any antiseptic which has proved itself capable of bringing about this highly desirable result. Astringents should never be used except in the first twenty-four hours after infection has taken place, and under the conditions in which most physicians first view their patients, they seldom have any opportunity to make use of them. In those rare instances where the patient presents himself for treatment immediately after the appearance of the discharge Lumb[40] advises the following daily routine for abortive treatment:

The patient having passed his urine, the meatus, glans and prepuce are cleansed with an antiseptic solution such as 1 to 3000 mercury bichloride, or tincture of green soap. A solution of potassium permanganate 1 to 4000, heated to 110° F. is placed in a container hung about 2 feet above the pelvis, and about 2 quarts of the solution allowed to flow very gently into the urethra. Following this 2 cc. silver nitrate, 5 grains to 1 ounce, is injected into the urethra where it is held without massage for the space of ten minutes; the patient then holds his urine as long as possible, which is usually at least two hours. This treatment should be given three times on the first day with a four- or five-hour interval between each treatment. The same treatment is given on the second day, as well as on the third, this time however, employing a 2 per cent silver nitrate solution for the injection. A specimen of urine is obtained on the morning of the fourth day, which is centrifuged and examined for gonococci. If the abortive efforts have proved successful only a few of these organisms, together with a small number of pus cells, will be visible.

The irrigations and injections are continued for a week, at the end of which time the permanganate solution is replaced by zinc sulphocarbolate, 1 to 1000 and the silver nitrate used only once, in the morning. By the tenth day the meatus should be dry and neither pus cells nor gonococci should be detectable in the urine. Should evidences of pus still persist the treatment should be continued for three or four days longer, the urine being frequently examined in the meantime. Several other methods of abortive treatment have been advocated, descriptions of which may be found in text-books devoted to the treatment of venereal diseases.

Fully-developed cases may be locally treated by irrigations, injections and instillations, each method having considerable backing

among those most widely experienced in the treatment of gonorrheal infections. For irrigation various solutions such as potassium permanaganate beginning with 1 to 12,000 and reducing gradually to 1 to 8000; acriflavine; zinc permanganate, most valuable toward the end of the attack; oxycyanide of mercury and mercurochrome, and silver nitrate, have all been enthusiastically recommended. The authors have found mercurochrome very inefficient, and have now altogether abandoned its use. Silver nitrate usually serves best in the concluding stages of the acute attack, for if employed early it retards the subsidence of the inflammation by its irritative action. These irrigations should be continued until the meatus is dry on getting up in the morning, the urine practically clear, and no discharge during the day, even after vigorous exercise. The prostate and Littré's glands should prove normal after careful examination. Should the discharge reappear, the cause of this relapse must at once be ascertained, and treatment renewed until complete cure is established.

Injection can only be regarded as a more or less unsatisfactory substitute for irrigation. It can be carried out by the patient himself, when it is impossible for him to present himself at the physician's office, but he should be very carefully instructed in its performance and should be kept under observation as closely as may be. A blunt-ended Chetwood syringe is sterilized by boiling and about 2 drams of the prescribed solution slowly injected into the urethra, especial emphasis being laid upon the importance of not using any force. The patient should precede the injection by urinating and then cleansing the meatus thoroughly with soap and water. The solution should be retained in the urethra for a full five minutes, accurately timed, not guessed at, and the lips of the meatus should not be held together in order to retain the solution, as this forces the fluid out of the fossa navicularis and away from the meatus where its action is most desirable. The avoidance of all "squeezing" or rough handling of any sort should be strictly enjoined. The solutions most commonly prescribed for injection are protargol 0.25 to 2 per cent solution; acriflavine from 1 to 4000 to 1 to 1000; argyrol in 5 to 10 per cent solution. Albargin is sometimes used in a 1 per cent solution or as an ointment.

Vaccine Therapy.—Vaccine therapy undoubtedly has value in promoting increased resistance of the blood to the invading bacteria; in serving to set up an active attack upon those organisms which have already penetrated the mucous membrane of the urethra, so that they are protected from the action of any irrigations which may be in use, and when the attack appears to have subsided, in acting as a test for cure. It is self-evident that the best vaccine to use for this purpose is the one which can be administered in the largest amount without causing the patient to suffer any toxic effects; that is, one inducing the least local or general reaction and productive of the greatest number of specific antibodies. Thomson[69] has devoted much attention to the production of gonorrheal vaccines, his prime object being:

(1) The efficient removal of the endotoxins from the germs to enable massive doses of vaccines to be given, and (2) to remove the poisons by a gentle process which will not so alter the germ substance as to destroy its antigenic or immunizing power. Thomson has had constructed a detoxicating machine, thus substituting mechanical disintegration of germs for the use of chemicals, by the use of which he has been able to produce a vaccine which can be given in an initial dose of about 20 millions, working up to 100 millions. This vaccine is the most efficient yet produced for the therapy of gonorrhea.

Serum Treatment.—Serum treatment has never been demonstrated to be of any practical value, although in some of the complications of gonorrhea, such as arthritis, prostatitis or epididymitis, it has in certain cases appeared to be beneficial.

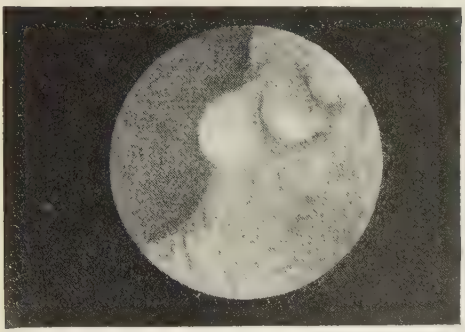
Electrolysis, high-frequency currents, and *diathermy* have all been reported as useful in the treatment of gonorrhea. As the gonococcus is killed by a comparatively low degree of heat, the application of this agent in different forms would seem to have a reasonable basis. The objection to the use of any of these agents is that each necessitates the introduction of instruments into a greatly inflamed urethra, a procedure to be avoided whenever possible. Hot sitz baths have seemed to produce excellent results in certain hands, but the necessity of keeping the bath at a very high temperature for some length of time and the constant skilled attendance absolutely essential, make this a difficult treatment for general application.

Tubercular Urethritis.—Reports of tubercular infection of the urethra are decidedly uncommon, some authors even going so far as to say that it is very doubtful if there is such an entity as primary urethral tuberculosis, that this lesion appears more as an incident in a generalized uro-genital tuberculosis than as a distinct disease. Urethral tuberculosis, however, assumes the character of a distinct disease in proportion to the extent of the implication of the anterior urethra. When the posterior urethra only is involved, it is hardly to be distinguished from tuberculosis of the bladder or prostate.[9] If the urethral lesion is an extension from the bladder or the organs of the seminal tract it is unlikely to produce any localizing symptoms, so that it will frequently go unrecognized, or will only be discovered by accident.

Frequency.—Some twenty years ago Chute on reviewing the scanty literature relating to this lesion noted that Ahrens gave the findings of several observers as to the frequency of urethral tuberculosis, all being based on autopsies. Steinhal is quoted as having found 6 instances of urethral involvement in 24 cases of uro-genital tuberculosis; Krzywicki, 5 instances in 24 cases; Pavel in 1455 autopsies on tuberculous subjects found uro-genital tuberculosis 380 times, but urethral lesions in only 7 of these cases. Hallé and Motz stated that for the twelve years preceding 1902 there had been at the hospital Necker from 12 to 15 deaths a year from genito-urinary tuberculosis, but

during that time they had found but 12 cases where the urethra was involved. We have been unable to collect any recent data concerning the incidence of tuberculosis of the urethra.

FIG. 93 (Pelouze).—Lesions of the sphincter margin in tuberculosis of the posterior urethra.



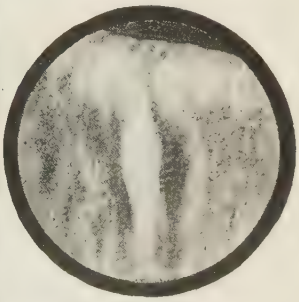


FIG. 94 FIG. 95

FIG. 94 (Pelouze).—Lesions at the sphincter margin and lateral urethral wall in tuberculosis of the posterior urethra.

FIG. 95 (Pelouze).—Fusiform lesion of the prostatic decline.

Etiology.—It is probable that a previous gonorrhea, especially if the infection has become chronic and lesions of long-standing are present in the urethra, would predispose to the engrafting of a tubercular process upon that particular area. Periurethral tuberculous lesions are derived through the lymphatic system from a nearby tuberculous source.[7] Baumgarten is quoted by Ahrens as having produced urethral lesions of tuberculosis in a male rabbit by the injection

of tubercle bacilli. He considered this result merely as a confirmative illustration that infection from without was perfectly possible, and that the urethra displayed no particular immunity to the tubercle bacillus. He believed that sexual desire was usually diminished in those suffering from genital tuberculosis, and for this reason oppor-

FIG. 96 (Buerger).—Lesions seen in tuberculosis of the urethral wall.

FIG. 97 (Buerger).—Elongated lesions of the postmontane fossa in tuberculosis.

tunities for such a mode of infection were relatively rare. Chute was unable to find a single recorded instance where urethral tubercular infection was believed to have taken place through sexual intercourse.

Symptoms.—Some years ago Pelouze[50] called attention to certain pathological conditions in the urethra which he regarded as invariable

local manifestations of a more or less active tuberculosis elsewhere in the body. He had observed in the posterior urethra small, slightly pedunculated or sessile masses of tissue springing from a mucosa that seemed little, if at all, inflamed. These bodies vary considerably in size, are of a pearly-white, rarely red, color, and minute bloodvessels can be seen traversing their smooth unbroken surfaces. At an early stage these are apparently solid masses of tissue that later seem to undergo a cystic change. In this cystic stage they are easily ruptured and a whitish substance exudes. When ruptured they leave an abraded reddish surface, usually circular in outline, with a small shred of white tissue attached to the edge.

FIG. 98 (Pelouze).—Diagram showing the usual sites of the lymphocystic lesions in tuberculosis of the posterior urethra.

These masses are usually upon the lateral urethral walls, just distal to the vesical neck, but may occur upon almost any portion of the prostatic urethral wall or verumontanum. Histologically, they are typically tuberculous tissue, with the caseating tendency of such tissue. Tubercle bacilli are readily demonstrated in the zones surrounding the areas of caseation. Pelouze believes that these bodies appear very early in the course of a tubercular infection, often before there is any possibility of proving the presence of tubercle bacilli, either in the lungs or genito-urinary tract, and that their recognition has high diagnostic value and should always stimulate the examiner to make a minute search for evidence of tubercular infection elsewhere.

The lesions of urethral tuberculosis have been arranged under three headings:[9] Those of the mucous membrane, those of the corpus spon-

giosum, and those of the periurethral tissues. Of the mucous lesions, the ulcer is the most common, granulations and diffuse erosion probably going rapidly forward to ulceration. Lesions of the corpus spongiosum are usually direct extensions of those of the mucosa; they may be infiltrations, ulcerations extending into the tissues, or cavities filled with pus and granulations. In the periurethral tissues we may find small abscesses resembling the suppurative folliculitis seen in pus infections, or again, the whole perineum may be infiltrated, or converted into one or several cavities filled with pus and granulations.

Symptoms of urethral tuberculosis are similar to those of urethritis from other causes, increasing frequency of micturition and tenesmus being common, and hematuria not infrequent. There is usually a thin slightly purulent discharge, and *ardor urinæ* is likely to be distressing. If the infection has extended to the submucosal structures, an attempt to pass a catheter may reveal the fact that there is a considerable induration and infiltration, which renders instrumentation difficult, or rarely, impossible. Examination through the urethroscope will show the ulcerative appearance characteristic of tuberculous lesions elsewhere in the genital region.

Treatment. Tuberculosis of the urethra should be treated along the lines laid down in the section on genital tuberculosis (page 290). It has been a frequent observation that when measures are taken to extirpate a neighboring tubercular process, the condition in the urethra tends to undergo spontaneous healing. The peculiar liability of the urinary canal to suffer secondary infection makes the prognosis grave in all cases, but this is no more true of the urethra itself than of its auxiliary structures. In the earlier literature there are several records of amputation of the penis, but it is doubtful if such a measure would prolong the patient's life sufficiently to offset his repugnance to such a mutilation. In surgical treatment of a generalized tuberculosis, the operator would naturally consider any lesions of the posterior urethra which were direct extensions from the prostate or vesicles.

Local Measures.—Local measures such as are advised for tuberculous cystitis, may be of benefit in selected cases, but in general, instrumentation of every kind is to be avoided as much as possible. In the not unlikely complication of stricture, dilatation should be practiced with the utmost caution, and it is more than likely that internal urethrotomy will be necessary to establish drainage. The greatest reliance must however, be placed upon building up the patient's general condition, and in those few cases where the urethral tuberculosis is not an extension from other genito-urinary foci, it is probable that general hygienic measures offer the only opportunity for recovery.

Urethral Abscess.—*Folliculitis* is frequently a troublesome complication of gonorrhea. During the first few weeks of the disease the gonococci often invade the small urethral glands, so that it may at times be possible to palpate these glands as small nodules upon the

under surface of the penis. Inflammation may be set up in the glands from a variety of causes, among which may be mentioned ingestion of alcohol, frequent erections and nocturnal emissions, and trauma from accident or careless instrumentation. On looking through the urethroscope the angry and inflamed state of the glandular orifices is plainly seen, and in cases where the glandular involvement is sufficient to permit palpation although the ducts are still open, slight pressure commonly causes a drop of pus to exude upon the surface. If the ducts continue patent so that drainage is free, these small abscesses seldom cause serious trouble and subside quickly under suitable treatment.

But if the congestion be very great, the orifices of the glands will be closed off by the inflammatory swelling, which prevents escape of the secretions and favors the formation of an abscess which may rupture into the periurethral tissues, although more frequently the mouths of the ducts are freed by the pressure of the abscess contents which is forced through them and appears at the meatus as a mucosanguinous discharge.

Periurethral Abscess.—Periurethral abscess makes itself manifest by palpable tumor formation with extension of the area of inflammation, infiltration of the surrounding tissues and great redness and tnederness of the skin. Often the skin will adhere to the encysted inflammatory mass, so that the abscess "points" and evacuates upon the external surface. These abscesses are most likely to be located in the fossa navicularis, probably because there are more glands here than in other parts of the urethra, and also because it is more subject to the trauma which is an almost invariable accompaniment of a patient's efforts to "treat himself." A single abscess usually appears upon one side of the frenum, but multiple ones may arise on both sides, so that all the surrounding tissue will have an edematous appearance. If the abscess gathers a short distance anterior to the bulb, it is likely to prove more severe and intractable than those of the fossa navicularis.

The metamorphosis of a folliculitis to a periurethral abscess can usually be avoided by prompt recognition and treatment. The first suggestion of inflammation of the follicles should be the signal for discontinuing all irritating influences, especially medication and instrumentation. If preventive measures do not abort the trouble, the pus cavity should be promptly incised to prevent spontaneous evacuation which is almost certain to result in fistula formation, a condition most obstinate and trying to the patience of all concerned. In extreme cases rupture may take place within and the ulcer "point backward," thus favoring urinary infiltration which may result in irreparable structural damage.

Syphilis of the Urethra.—Chancre.—Chancre of the urethra is of comparatively rare occurrence. Thompson[68] in 216 genital chancres found but 2 in the urethra, but thinks it probable that in a certain percentage of cases of syphilis where no genital scars can be found,

the original lesion may very well have been concealed in the urethra. Chancre of the urethra occurs either on one of the lips of the meatus, or about $\frac{3}{4}$ inch further up the canal. If it is located in the canal it is apt to cause pain when the urine passes over it, and to be associated with edema and induration. There is also likely to be a purulent discharge, which on cursory examination might suggest a gonococcal infection.[20]

Concealed Chancre.—Concealed chancre in the male is very difficult of diagnosis, and competent observers have noted[77] that the classic symptoms of disuria, marked urethral discharge and obstructed urinary stream are not commonly found. However, in the majority of such cases there will be a mucous or watery discharge, the lips of the meatus will be flattened and a reddish zone of mucous membrane be visible in this region. There will also be edema of the prepuce, for which no adequate cause will be in evidence. The most important diagnostic finding however, is the presence of induration of the tissues just beyond the lips of the meatus.[63] The diagnosis of syphilis must finally rest on the examination of the discharge, that of gonorrhea is much more purulent and contains gonococci, while in the sero-sanguinous exudate from a urethral chancre *Spirochæta pallida* can be demonstrated.

Macular Lesions.—Macular lesions as a rule appear near the meatus, though occasionally they are found at some distance within the urinary canal. Pain is commonly limited to itching or burning on urination, and will be accompanied by a slight viscid discharge. Occasionally, however, the pain is severe and the discharge may be muco-purulent, or sanguinous.

Cylindrical Syphiloma.—Cylindrical syphiloma are described by Thompson as a rare syphilitic manifestation in the urethra which occurs as a regular cylindrical infiltration of a segment of the urethra extending from 4 to 8 cm., rarely more, along the course of the canal. It has been described as feeling upon palpation, like a penholder or a pipe-stem, but more aptly by Fournier, as like a sound in the urethra. It may exist either with other manifestations of syphilis of the urethra, as isolated gummas, or it may be an entirely independent lesion. Also there may be small nodules along the course of the "cylinder" which are actually gummas. This type of lesion is made up largely of sclerous tissue and is therefore, very resistant to treatment, more or less permanent contraction of the lumen of the urethra remaining. According to Rougier,[55] Veale believes syphilitic infiltration of the urethral wall is very common, but Alex-Renault claims, on the other hand, that it is a very exceptional manifestation of syphilis.

Gumma. Gumma of the urethra is relatively easy of diagnosis, and cases have been reported with much more frequency than those of other luetic affections of this structure. Two types of gummatous infiltration are distinguished; those occurring primarily in the urethral canal, and those propagated by continuity. The first type is undoubtedly rare, very few instances having been reported in English.[55]

Those due to extension from neighboring structures are of more frequent occurrence, but still by no means a clinical commonplace. At the outset a urethral gumma may offer some impediment to the flow of urine, but it very early softens and breaks down so that the stricture is of short duration. The breaking-down process usually produces hematuria, but it is not likely to be severe nor prolonged enough to alarm the patient, especially as pain is wholly absent. An exception to this rule is a case recently reported from Brazil,[71] in which there was no venereal history but only one of having passed calculi five years before. Marked initial hematuria, first at extended intervals and then of almost daily occurrence, was naturally attributed to recurrence of the lithiasis. The urethroscope, however, revealed a huge gumma about 4 cm. from the meatus. There was no stricture, no pain during micturition and no enlargement of the inguinal glands, but the Wassermann reaction was positive, and the ulcer promptly disappeared under anti-luetic medication.

Diagnosis.—The diagnosis usually lies between tuberculosis, syphilis and malignancy. In tuberculosis the urethral lesions, as we have seen, are usually secondary to other tubercular foci, there is pain throughout the act of urination, the lumen of the canal will be narrowed and the discharge will contain tubercle bacilli. When the condition is one of malignancy there will also be pain, inguinal adenitis will be very marked, and the discharge will be fetid and sero-sanguinous, while the endoscopical appearance will usually be characteristic of malignancy.

URETHRAL CALCULUS.

Stone in the urethra is probably of more frequent occurrence than the relatively small attention it receives in literature might lead us to suppose. The great majority of calculi found in the urethra have their origin in the bladder, or even higher up in the urinary tract, but there is also a fair percentage of such concretions which are primary to the urethra itself.

Formation of primary calculi will depend upon the existence of abnormal conditions, such as enlargement of the prostate, the presence of a diverticulum of the urethra, a dilatation or a stricture. A few are no doubt due to trauma. If the urine is highly concentrated, it will have an important bearing on the production of these concretions, ammoniacal decomposition especially favoring the condition. Thompson[70] attributes the enormous number of urinary calculi removed from the natives of China in great measure to the climatic and laboring conditions under which the lower classes of Chinese live, these inducing elimination of water through the skin rather than the kidneys, with consequent high concentration of urinary salts. Deposits of such a pathological urine, if they come in contact with a section of the urethral wall where there is a congenital or acquired

variation from its normal configuration, are prone to make a nucleus of urinary calculus at that point.

FIG. 99.—Stone in the prostatic urethra.

Once formed, such stones may remain in the urethra for long periods. In Hirsch's case the stone was known to have been present for fifty-three years, while the patient recently seen by Galbraith[23] had first

observed the obstruction at the meatus twenty-three years before coming under observation. Neither of these had caused any especial inconvenience until shortly before medical aid was sought. Again, the stone may cause grave inconvenience, yet competent urologists be unable to detect its presence, so that the long train of urinary symptoms which it produces will be attributed to something else,[46] so that the unfortunate patient may spend years traveling from one clinic or specialist to another, yet never receiving any relief.

Formation in Diverticula. —Not only will stones tend to agglomerate in congenital diverticula, but also when a stone has arisen from some other cause or set of causes, its presence will frequently tend to promote diverticulum formation. Several such cases were noted by Watts[76] who thought that calculus might be an etiological factor by becoming engaged and embedded in the urethral wall, where the pressure of the urine behind it would eventually weaken the wall, so that it would expand and form the pouch.

Symptoms. —The symptoms of urethral calculus are more apt to appear gradually, and to have been in evidence for some time before the patient regards them as worthy of medical interpretation. The first evidence noted is commonly the diminishing size and force of the urinary stream, "dribbling," temporary or steadily increasing incontinence, retention and pain. The pain is often felt only on assuming some particular position, and is described as knife-like and radiating, though the radiation may be in almost any direction. Frequently, coitus will be painful and ejaculation impossible, but many patients have carried these stones from boyhood and become fathers of families without apparent difficulty. If the three-glass urine test is employed an accompanying urethritis may cause the first glass to be cloudy, and there may be evidence of inflammation discernible in all three glasses.[61]

Diagnosis.—The diagnosis can usually be made by the characteristic "feel" of the calculus when a sound is introduced into the urethra. The urethroscope is still more dependable. Palpation by the rectum will usually establish the presence of a circumscribed induration which is often movable and changes its position spontaneously, and pressure upon which elicits pain and produces a feeling of crepitus in the presence of more than one calculus.

Treatment. —Unrecognized calculi may induce periurethritis with subsequent suppuration and formation of a fistula. Less frequently an encysted stone may pass out at the meatus without surgical interference. In most cases, however, the surgeon will have to undertake their extraction. Through the urethroscope, the stone can sometimes be grasped with forceps and withdrawn without damage to the urethral mucosa. Dilatation with sounds may serve where there are small multiple stones. Surrounding the stone by a large number of filiform bougies, which are pushed beyond it on all sides and then withdrawn simultaneously bringing the stone with them, has

been recommended.[30] This would protect the wall of the urethra from injury, but can only be used in cases where the stone is not encysted. It has also the practical drawback of requiring more filiform bougies, 12 to 15, than are ordinarily at the surgeon's hand. If the stone is too large to pass the meatus, it can usually be crushed, or a meatotomy done, though this last is not desirable except in those cases where the orifice is abnormally narrow. External urethrotomy is frequently employed, but in the authors' opinion should be employed only when more conservative measures have failed.

NEOPLASMS OF THE URETHRA.

Benign Growths.—Papillomata.—Papillomata are of relatively frequent occurrence within the urethra in both its anterior and posterior portions. According to Doble[14] they may occur in enormous numbers, having been found growing from the whole mucous membrane of the urethra, sometimes even impeding the flow of urine. The bulbous urethra is their most common location. They are papillary projections and appear in various forms. They may be flat sessile warts, which urethroscopically have been taken for erosions in the mucous membrane. Large fleshy warts and long thin strands like seaweed may be seen. These are very soft and friable and in color almost every shade of red. A single papilloma is likely to arise in that part of the urethra lying between the anterior layer of the triangular ligament and the peno-scrotal junction, while the multiple growths occurring in groups or "nests" are commonly found near the meatus, usually coincident with similar papillary exuberences on the glans and prepuce.[44]

Urethroscopical Appearance.—These growths are more prone to be sessile than pedunculated, often having a cleft surface and displaying numerous outgrowths. They are rough, warty excrescences, pale pink in color and presenting a somewhat glistening appearance. The multiple growths are rather broad at the base, of a distinctly "cauliflower" type, while those which occur singly have a thinner base and give off thin delicate fibrillæ. All of them are easily rubbed off, leaving a freely bleeding base, so that diagnosis by the aid of the urethroscope alone is very easy.[15]

Polypi.—Polypi usually lie in the folds of the mucosa lining the fossa navicularis and the bulb. They are very prone to induce a discharge, but in their concealed position are often overlooked, so that the reason for the discharge remains a mystery. But as they probably arise as a result of irritation, it is perfectly possible for them to be a *result* instead of a causal factor. The establishment of this point however, has an important bearing upon treatment.

It is essential that any growth appearing in the urethra be examined early for the possibility of malignancy is ever-present. All types of papillomata are readily removed through the urethroscope and the bases cauterized. Fulguration has also been very successfully

employed.[44] Recurrence after excision is very common and the tendency of any such benign condition to later become malignant must never be forgotten. Most of these patients give a history of gonorrhea, and the possibility of a persistent discharge which is laid to a chronic urethritis being actually due to a new growth, should lead to the employment of the urethroscope more frequently than is the practice at present.

FIG. 100.—Benign cyst of urethra presenting through the meatus. This is a very rare condition, no mention of it being found in the literature.

Cysts.—Cysts of the urethra except when associated with tuberculosis are exceedingly rare. The one case of the author's was entirely benign and easily removed *in toto* under local anesthesia.

Malignant Growths. — Carcinoma. — Carcinoma of the urethra is ranked as a rare condition, Kretschmer[35] in 1923 finding but 80 authentic recorded instances. A study of the cases thus collected shows that the majority of these urethral growths are of the pavement- or squamous-cell type. The development of the squamous-cell carcinoma of the penile urethra can be explained on the basis of metaplasia as a result of which patches of leukoplakia form, which then undergo malignant degeneration.

Often the discovery of a urethral carcinoma will have been preceded by urinary difficulties of various kinds which have been present over a long period, but in younger patients the appearance of the neoplasm is often quite unheralded. As in carcinoma occurring elsewhere, there is reason to believe that preceding trauma or irritation may be a contributing factor. The majority of those which follow long-standing infection and injury are in men of "cancer age" and are likely to be found where stricture formation is most common, that is, in the cavernous and membranous urethra. Occasionally they appear in the penile urethra but only rarely in the fossa navicularis.[57]

Symptoms and Diagnosis.—As a urethral neoplasm is likely to set up a partial obstruction to the lumen of the canal, the first symptoms noted by the patient will be those ordinarily associated with stricture. There is commonly also, a discharge which, in patients who have previously suffered from gonorrhea, and these are in the great majority, will sometimes contain gonococci. Retention not infrequently occurs, and in general these early symptoms most resemble those of stricture induced by chronic urethritis.

Viewed through the urethroscope, such a growth when seen early, may be either red and papillomatous, or appear as a warty white infiltration, resembling a warty leukoplakia of the tongue. According to Doble, the chief characteristic of the early stage is the great induration, but O'Neil[48] has said that while the "wooden" induration of the tissue about an old urinary sinus may be very suggestive of malignancy, he recalls at least one case where such a diagnosis having been made, a section removed at operation proved to be a chronic inflammation only.

Following the first symptoms of disturbed urinary function, hematuria and purulent discharge, the advancing disease will produce swelling of the perineum and very likely extravasation of urine. Pain, except during the act of micturition, is seldom noticeable until the condition is far advanced. The inguinal glands early show evidence of adenitis.

Diagnosis. -The diagnosis must rest upon the history and observations made during physical examination, but usually this cannot be confirmed without examination of a specimen of excised tissue. As O'Neil says: "On incision the true character of the lesion may be discovered, but not infrequently it is not until a second operation is undertaken for lack of closure of the fistula, or relief of the supposed stricture after drainage of an abscess, or the wound has taken on the appearance suggestive of malignant disease, and a section of tissue shows its true nature." And by this time the patient has usually passed beyond hope of aid from the surgeon.

Treatment.—Treatment may be either by surgery or radium application, or a combination of both methods. The prognosis is grave under all conditions, but favorable results are reported with sufficient frequency to encourage both physician and patient to use every effort

to effect a cure. Statistics recently collected in Germany,[54] regarding 25 cases of carcinoma of the male urethra which underwent operation, show that 4 patients died as the immediate result of operation; and 5 of recurrence within six months. Thirteen patients had remained well for from six to ten months, and in 3 cases, there had been no recurrence for two years or more. In Kretschmer's case there was no sign of recurrence two years after radical operation.

Radium.—Radium has been used to good advantage in a number of cases of carcinoma of the female urethra, but reports of its employment upon males are very few. To Culver and Forster[13] in operable cases, whether in the male or female, it seems logical to use both surgical measures and radium, or massive doses of roentgen-ray. The first mentioned procedure was carried out in the case reported by Scholl and Braasch.[57] Two months after the operated area had healed except for a perineal sinus, 350 milligram-hours of radium were applied to the urethra in the region of the scar, through the sinus. The patient who was aged forty-eight years, at the time of operation, was alive five years later, but "whether or not there has been recurrence was not ascertained."

Sarcoma of the Urethra.—Sarcoma of the urethra is an extremely rare condition, so that Mark,[45] addressing the American Urological Association in 1908 could state that a primary sarcoma of the male urethra had never been recorded. Three years later he reported such a case which had occurred in his own practice. In 1898, Mariachess[43] a Russian, reported an amputation of the penis for sarcoma which showed no tendency to recurrence after three months, but no pathological confirmation of the diagnosis was offered. The symptoms, course and grave prognosis of sarcoma of the urethra parallel those of sarcoma elsewhere in the genital tract.

STRICTURE OF THE URETHRA.

Urethral stricture may be defined as any diminution of the caliber of the lumen of the urethra resulting either from the proliferation of cicatricial tissue following trauma or inflammation, or because of a congenital malformation.

Etiology.—The great majority of strictures are an aftermath of gonorrhea. In Young and Geraghty's[80] series of 400 cases, 90.05 per cent were due to this cause, and they found their figures to be practically identical with those of Christen,[8] gathered from a like number of cases. But even without resort to exact statistics, it is not wide of the mark to say that 9 out of 10 of the strictures encountered in clinical practice will be due to gonorrhea.

Trauma.—Trauma, either from external violence, or because of unwise medication with caustics, or rough and ill-advised use of instruments, produces some strictures, and the small remainder can probably

be safely classed as congenital. Congenital stricture has already been discussed (page 313).

It is a common practice to classify strictures as *permeable* or *impermeable*, but such a differentiation is not very definite because, as has been aptly remarked,[3] whether a stricture is permeable or not often depends as much upon the surgeon and the instruments available as upon the stricture.

Spasmodic stricture arises from contraction of the muscles of the deep urethra which may be the result of some abnormal constituent of the urine causing irritation; to the presence of vesical calculus; to posterior urethritis and urethro-cystitis, or to irritation produced in the deep urethra by excessive coitus, alcholic excess or other causes of over-stimulation. Sometimes the cause is purely psychic. Spasm occurs only in the membranous urethra, and may sometimes be very difficult to differentiate from true organic stricture at the bulbo-membranous junction. As Keyes has said: "Organic and spasmodic stricture often coexist. Indeed, organic stricture is the most common cause of spasm, and spasm may be the notable symptom of an organic stricture of large caliber." Chetwood points out that if a blunt instrument be held firmly against the face of a 'spasmodic stricture,' with gentle but steady pressure, the contraction often yields suddenly, and the instrument enters, causing a certain amount of pain; but in the case of true stricture, the resistance is firm and tight, and is not suddenly overcome by the gentle force of an instrument larger than the caliber of the stricture. Urethral spasms always relax under anesthesia, so that it has more than once happened that when a patient had been fully made ready for operation upon his stricture the surgeon was quite unable to find it at all.

When the spasmodic nature of the retention has been established, it can usually be relieved by the application of heat—preferably a "sitz bath"—while the offending muscles may often be stretched by inserting a large sound, and the irritability of the posterior urethra lessened by application of some solution such as silver nitrate. It is essential that the physician search out the basic cause of the difficulty, which is quite as often mental as physical, and apply the appropriate treatment, whether it be operative intervention or psychotherapy.

Organic Strictures.—When stricture is the result of gonorrheal urethritis, the mucous membrane will be indurated and thickened. Periurethral contraction will have taken place because of the formation of fibrous tissue, this tissue formation being the result of reabsorption of the infiltrating elements deposited in the submucous tissue while the acute inflammatory process was going on. When this process healed it induced sclerotic changes which retracted the tissues and narrowed the lumen of the urethral canal. Strictures usually occur in the most vascular portions of the tube, especially at the subpubic curvature of the bulb where chronic urethritis is likely to have its focus. That the hardening and thickening which leads to stricture is a gradual

process is evidenced by the length of time between the appearance of these obstructions to urination, and the point at which the patient has been deemed wholly cured of his urethritis; frequently a year or

FIG. 101.—Stricture of the urethra occurring at the bulbomembraneous junction, which is the commonest site of stricture resulting from long-standing gonorrheal urethritis It will be noticed that there is dilatation of the urethra both in front of and behind the point of stricture.

more may pass before retention is observed. Once the impediment has arisen the small amount of urine which it at first holds back is yet sufficient to induce irritation of the tissue behind, so that the process of inflammation and repair by scar tissue may continue as a vicious circle. At times there will be but a thin band of this cicatricial tissue; again it will be sufficient to form a good-sized irregular mass.

Viewed postmortem, such a stricture will have a yellowish-white color, and when seen through the urethroscope during life will show no evidence of hyperemia, swelling or inflammation. In advanced cases a band of scar tissue will have wholly replaced the mucosa and penetrated to the corpus spongiosum. Beyond the stricture the urethral wall will appear eroded and usually much distended.

Symptoms.—When stricture exists there is likely to be a continuous discharge, so that the possibility of its existence should be suggested by any intractable and long-standing "gleet." But whether or not the gleety discharge accompanies the stricture, it will always be possible to detect shreds in the urine. These are small, short, or granular in character, though occasionally they will appear heavy, thick, twisted and prone to sink quickly to the bottom of the urine receptacle. On account of the increased acidity of the urine, the stricture is irritated and contracts so that the symptoms of posterior urethritis are augmented, while the urine becomes cloudy. These exacerbations are usually regarded by the patient as new attacks of gonorrhea.[52]

Frequency of Urination.—Frequency of urination compelling the patient to rise several times during the night is a common complaint at this time, sometimes accompanied by painful erections, and in some cases the stricture will be so located as to prevent the complete ejaculation of the semen, which either dribbles out of the urethra after the completion of the sexual act, or flows backward into the bladder, whence it is later evacuated in the urine. Decline of libido, or occasionally, complete impotence, may also take place.

Effects of Retention Due to Stricture.—Though the stricture is practically never so tight as to wholly prevent the passage of urine, the stream is frequently reduced to a mere thread, and the retention may give rise to spasmodic pain in the bladder, even though that viscus is itself perfectly healthy. Long continuance of the strictured condition will, however, eventuate in vesical inflammation, and the ever-present back-pressure may in the end affect the ureters and kidneys. Dilatation of the urethra behind the point of stricture will soon produce infiltration of the tissues of the urethral wall, and this will be followed by extravasation of urine with the very probable sequel of perineal abscess and urinary fistula.

Diagnosis.—If a sound is introduced into the urethra it may be possible to pass it all the way to the bladder without impediment, but on attempting to withdraw it, the instrument may be grasped so firmly that it will be difficult to get it out. This may indicate the existence of a *wide-caliber stricture,* or may be simply due to a urethral

spasm. True organic stricture will always be perceived when attempting to attain the bladder, the sound being stopped when the constricted portion of the lumen is attained. It will then be necessary to withdraw the instrument and try those of smaller caliber until one is found which can pass through the narrowed opening. The stricture can thus be located and measured.

Treatment.—Dilatation under strictly aseptic precautions is the most commonly accepted mode of treatment. Dilatation is the foundation stone upon which all the other forms of treatment rest contributing to them a permanency which can be attained by no other means. In all methods, with the possible exception of those rare cases in which a perfect immediate result can be obtained by complete resection of the strictured portion of the urethra, dilatation becomes a necessary adjunct, if permanency of cure is to be maintained. Dilatation, aside from the mechanical stretching produced, unquestionably leads to a certain amount of resorption of the scar tissue. The greater the extent to which this resorption and softening take place, the better, of course, will be the end-result. The effect produced by the sound in the gradual stretch of the tissues concerned in stricture formation is somewhat analogous to that produced by massage on cicatricial areas in other portions of the body. Guyon says that the sound has a therapeutic action on the urethral walls and should be used with that end in view.[80]

After all aseptic precautions have been observed a steel sound is very gently introduced as far as the stricture. Dilatation is sometimes begun with filiform bougies attached to "followers," by means of which the caliber of the largest sound which will pass, can be determined. The first sound used should be capable of slipping into the bladder practically of its own weight; force sufficient to cause trauma, or even irritation, should never be employed. Not more than two sizes of sounds should be inserted at the first sitting, and about seventy-two hours should be allowed to elapse before another attempt at dilatation is made. An instrument slightly smaller than the last passed should be put into service at the beginning of each repeated treatment, and not more than three or four successive numbers of the caliber scale introduced at any one session. As the lumen of the urethra gradually increases in caliber and the tendency to contract after dilatation is more and more overcome, the time between treatments should be gradually extended. The length of time "sounding" must be continued will vary with the individual under consideration. In general, if the urethra can be stretched so that it will receive a 25 to 30 (French) sound after an extended interval of non-intervention, it may be considered a good result. The Kollmann dilator may prove efficient after sounds have increased the size of the lumen, but if used too early, there will be great danger of injury to the urethra that will defeat its own purpose. The object in dilating the constriction is to cause a necrosis of the most constricting fibers by damage so slight that it will

not be repaired by scar-tissue but will undergo absorption, thereby lessening the constriction.[3]

Operative Treatment.—Strictures which cannot be successfully dilated must be incised. This is necessary in those cases where the stricture contracts after every dilatation, no matter how long the instrumentation process is continued, or again, where the strictured area is too extensive, or the contraction ring too tight, to admit of any attempt at gradual dilatation. Internal urethrotomy is indicated, according to Sir Henry Thompson, the great English urologist "in almost all strictures affecting the external meatus of the urethra; and for many cases of stricture situated about the middle of the spongy portion, for which dilatation has proved unsuccessful, it is the most efficient treatment existing; also in those rare cases in which the urethra is narrowed and indurated at many points."[67] These rules, however, are applicable only to the anterior urethra. If the stricture is located in the deep urethra, or if there is marked urinary retention, external perineal urethrotomy will be the operation of choice. No matter what surgical procedure has been selected, continuous dilatation will form the important feature of the after-treatment.

SURGERY OF THE URETHRA.

Anesthesia.—Anesthesia for all varieties of urethral intervention can be obtained with perfect safety by the sacral or parasacral routes. The method to be used has already been briefly described in connection with surgery of the penis (page 161) and the whole subject of sacral anesthesia will be considered at greater length under prostatic surgery (page 441).

Internal Urethrotomy.—This operation is not employed very frequently at present, owing to increasing skill in the dilatation of stricture, which has tended to do away with "cutting" as a means of relief for that condition. Operation however, not infrequently becomes necessary in cases where the stricture is so resilient that it will not permit adequate dilatation; where the tissue has become so dense that dilatation is impossible, or where the patient for economic reason, or possibly from lack of intelligence, cannot be submitted to the lengthy process of gradual enlargement of the urethral lumen. Again the urethra may be in such a condition as to be intolerant of any instrumentation, or vesical and renal complications make immediate restoration of the caliber of the urethra imperative.

The administration of a urinary antiseptic should precede internal urethrotomy, and the strictest attention be given to every point of antiseptic preparation. The patient is placed in the lithotomy position and the caliber of the stricture, as well as the length of the space intervening between it and the meatus, ascertained by measurement. If the stricture is very tight, the Maisonneuve urethrotome must be employed, as the Otis instrument cannot be inserted if a 13-French

sound is unable to pass. The Maisonneuve urethrotome is attached to a filiform, which is so held that the groove of the urethrotome faces the median line of the penile dorsum, and the instrument inserted in the same manner as the initial step of catheterization. When the instrument can be demonstrated to have passed the stricture, the knife is fitted into the groove provided for it, and passed through the contracted point, thus severing the strictured tissue from before backward.

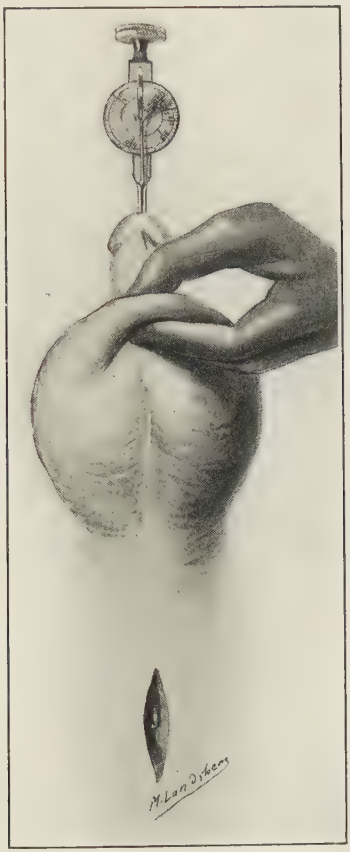


FIG. 102.—Internal urethrotomy. Otis urethrotome introduced through the anterior urethra to the point of incision.

The Otis Urethrotome.—The Otis urethrotome consists of two parallel bars which can be separated by adjusting a thumb-screw on the handle. These bars are supported by the elevation of smaller bars as the large ones are opened. The upper main bar has a groove through which knives of various sizes may be slipped. The instrument is closed and pushed up the urethra until its point has passed the stricture. Holding the blade exactly in the upper median line, the

thumb-screw is turned so as to separate the bars as far as possible without tearing the tissues, which should only be rendered tense enough to facilitate division of the stricture. With its sharp edge against the urethral roof, the knife is now drawn forward, so as to divide the stricture completely. The blade being drawn back to its groove, the bars should be separated still further, and if the characteristic resistance is still felt, it indicates that the division of the stricture is not complete, and further cutting will be necessary.

When the stricture has been satisfactorily severed, hemorrhage can be prevented either by bandaging the penis and making counter-pressure on the perineum against a catheter in the urethra, or cardboard splints padded with cotton, as recommended by Chetwood,

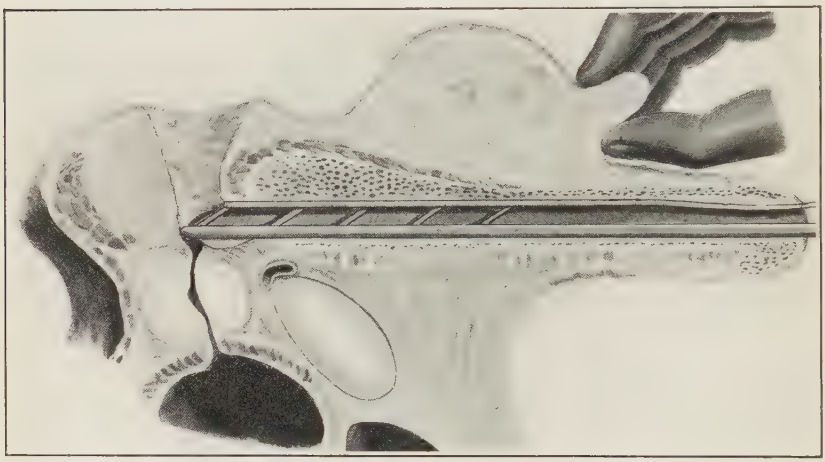


FIG. 103.—Internal urethrotomy. Sagittal view showing the Otis urethrotome properly placed, with the cutting blade pointed upward so that if the confines of the urethra are exceeded in the incision, it will extend into the partition between the two corpora cavernosa and no harm will result.

may be placed on the dorsal and ventral sides of the penis, held in place by a gauze bandage and strips of adhesive plaster, drawn tightly enough to check bleeding, while not sufficiently tight to prevent the passage of urine. Some operators insert an in-dwelling catheter which is permitted to remain for two or three days. Many surgeons, however, do not favor this.

Following internal urethrotomy, beginning about four days thereafter, a sound a size smaller than the measure of the incision should be inserted at regular intervals —four or five days —to insure the continued dilatation of the operated area, and this should be continued until all evidence of stricture has disappeared.

External Urethrotomy. —Where stricture of the bulbous urethra or of its perineal portion exists together with perineal fistula or sinus,

or possibly a prostatic abscess, surgical relief must take the form of external urethrotomy. This may be either with or without a guide, or the Harrison procedure, which is a combination of both internal and external urethrotomy, may be employed.

Perineal Section Without a Guide.—Perineal section without a guide is a rather inexact procedure and has little to commend it. External urethrotomy with a guide is a simple operation, whereas that without a guide is much more difficult and may prove exceedingly tedious on account of distortion and deflection of the urethra. In cases of impermeable urethral stricture, the point of contraction must be exactly located, and an attempt made to enter it with a filiform bougie. Frequently however, even the filiform cannot pass, which will make recourse to suprapubic cystotomy and retrograde catheterization necessary, as was recommended in repairing rupture. The Cocke procedure, which consists of perineal section into the urethra, or rather where the operator guesses the urethra to be, with the establishment of retrograde catheterization through the wound thus created, is dangerous and unscientific, and has no place in the resources of the modern urologist. The instruments devised by Sinclair[59] serve both for cystotomy and intra-urethral guidance. They consist of a trocar and cannula, oval, size 18-French, the cannula being $5\frac{1}{2}$ inches long and serving as a sheath for a straight observation cystoscope 5 inches long. If the patient has recently urinated, from 4 to 8 ounces of boric acid solution must be syringed into the bladder, the nozzle of the syringe being inserted at the meatus. After antiseptic preparation and the administration of the selected anesthesia, the trocar-cannula is passed through the bladder wall in the median line, 1 inch above the symphysis pubis, the penetrating instrument being held in a slightly oblique and forward direction so that it will approach the urethral orifice. The trocar is now replaced by a soft rubber catheter which may be pushed into the urethra, and will serve as a guide for external urethrotomy. Often after the bladder has been aspirated through the cannula, the relief of tension thus effected will be sufficient, after twenty-four hours, to permit a whalebone bougie to pass the stricture by way of the meatus, and has even made possible dilatation which obviated the necessity of cutting down upon the urethra.

Young's Procedure[78] consists in a median perineal incision from which two oblique cuts are made backward and outward, outlining an inverted Y. Division of the central tendon and recto-urethralis muscles exposes the vertex of the prostate as in perineal prostatectomy, while its anterior third, as well as the membranous urethra, are exposed by blunt dissection, the wound being held open by posterior and lateral retractors. A median incision into the membranous urethra and anterior prostatic urethra permits the edges of the urethral mucosa to be picked up with forceps, and a sound to be passed forward through the membranous urethra, thus establishing communication between the portions of the urinary canal anterior and posterior

to the stricture. The strictured tissue having been excised, the prostatic and membranous urethral incision is closed over a retained catheter, which is brought out through the wound in the bulbous portion, emerging from the anterior angle through the normal channel in front of the stricture.

Fig. 104

Fig. 105

Fig. 104.—External urethrotomy. Incision is made in the perineum and deepened to the point of a sound which is inserted into the urethra as far as the point of stricture. In case it is impossible to introduce an instrument to a suitable point in the urethra, the patient is placed squarely on the table, the incision being deepened to a point just under the symphysis pubis, because this is always a fixed point regardless of extensive distortion of other portions of the urethra. The viscus is identified by the eye or finger. A grooved director may then be introduced into the bladder and the anterior urethra incised with an Otis urethrotome.

Fig. 105.—External urethrotomy. Grooved director inserted through the posterior urethra into the bladder. Following this, the posterior urethra and vesical orifice are dilated with the finger and sounds.

External Urethrotomy with a Guide.—With the patient in the lithotomy position a filiform is introduced, or if the stricture is not too tight, the regular grooved staff may be employed at the outset. The instru-

ment is passed all the way to the bladder, so as to make sure that it has not entered a false passage. If it has been necessary to use the filiform, a grooved director is next passed in beside it, the filiform is then withdrawn, and while an assistant holds the staff so that the groove is readily palpable through the perineum, the knife is inserted about 4 cm. in front of the anus, and its point drawn backward along the groove in the director until it impinges upon the membranous urethra, a distance of not more than 1 to 2 cm. The wound should

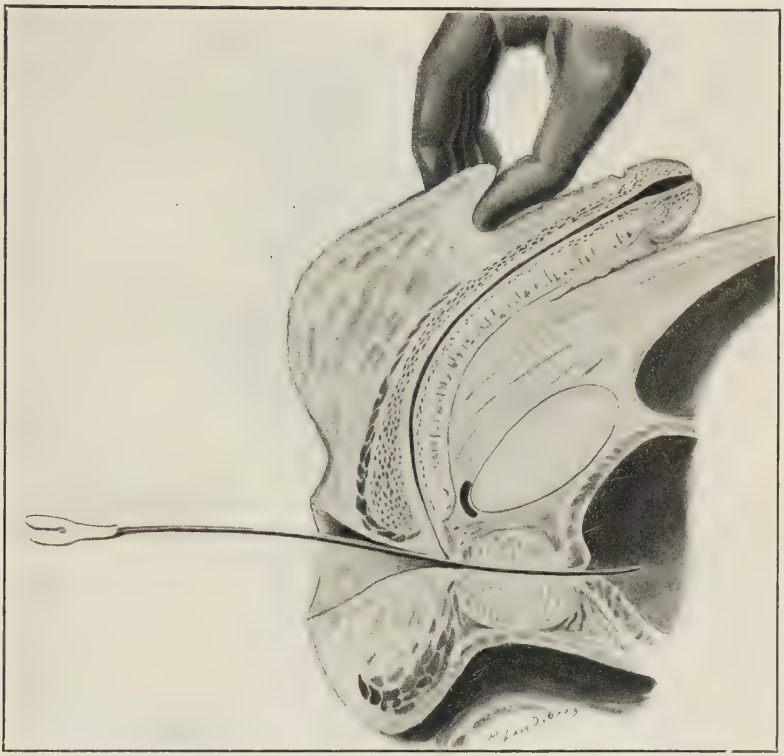


FIG. 106.—External urethrotomy. Sagittal view, showing the grooved director introduced through the posterior urethra into the bladder.

be large enough to open up the mucosa sufficiently to permit entrance to the operator's finger, which should come in contact with the bare staff, the mucous membrane being completely cut away. With the finger in the wound, the staff is now withdrawn, and the finger can then be passed back along the roof of the urethra and into the bladder. Should the incision of the stricture not be large enough to permit this passing of the finger, a grooved director must be passed in through the perineum and the strictured area still further incised upon it.

The exploring finger is now able to locate and recognize any existing

abscesses, calculi, or other pathological conditions, as well as to determine whether all the fibrous bands causing the stricture, have been severed. A rubber perineal tube should now be passed through to the bladder, and stitched to the wound to hold it in place. Keyes warns against packing the urethra around the tube as it is likely to excite much more hemorrhage when it is removed a few days later, than would have occurred in the first place. Furthermore, it encourages infection and delays healing. The tube may be kept clear by aspiration, and should usually be removed by the second day.

FIG. 107.—External-internal urethrotomy. After the strictures have been cut and sounds passed up to 30 F., a tube is inserted into the bladder and fixed in position with one silkworm-gut suture.

Operation in the Deep Urethra.—When the deep urethra is the part involved, it is better to follow the advice of Fuller,[22] and make a free longitudinal incision extending from the posterior base of the scrotum down to the rectal sphincter, thus splitting apart the entire perineum and opening the whole length of the bulbous and membranous urethra. All existing lesions can then be inspected and repaired and if necessary, an additional incision may be made in a stricture, so as to fully restore the lumen of the urethral canal. This operator avoids the postoperative use of sounds and makes it possible to suture the perineal incision by the employment of a "urethral splint." An ordinary rubber perineal drainage tube is passed along the lowest part of the incision into the bladder. Then another rubber tube the full caliber of the urethra, about 30 to 32 French, is passed as far as

the first perineal tube, its lower end cut off at an angle such as to fit snugly against the perineal tube. The deep urethra is then sutured over the urethral splint, and the perineal incision closed except where the tube emerges.

Other operations upon the urethra have already been described, those for the correction of hypospadias (page 131) and epispadias (page 135) being the most important. The treatment of periurethral abscess will be discussed in the chapter upon Cowper's Glands (page 363). The operation proposed by Maximilian Stern, of New York, has many advocates.

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CHAPTER IX.

COWPER'S GLANDS.

History.—The bulbo-urethral glands were first described by Méry of Paris in 1684, but when, fifteen years later, a more detailed account of them was published by William Cowper, the name of the English anatomist was attached to them, so that they were thenceforward known as Cowper's glands.

The first detailed modern study of these structures appears to be that of Gübler, forming the subject of his Paris thesis which was published in 1849, but our present knowledge of them really dates back no further than the two decades between 1870 and 1890, during which Englisch published his classic researches upon the urethra and its related glands. Since 1904, however, the careful work of Paul Lebreton[15] has stood as a standard, no more recent studies having come to our notice, which can in any way supersede the observations and conclusions of this French scientist.

Pathological Importance.—The importance of these small structures, particularly as regards their relation to the recurrence or persistence of urethritis, is by no means generally appreciated, a fact abundantly attested by the dearth of literature upon this subject. It is difficult to find in English anything more than the barest mention of Cowper's glands, and adequate discussion of their histology or pathology is wholly lacking. Except for the work of Englisch and Lichtenberg, the same may be said of German. Only in France, the land which has given birth to such a race of zealous urologists, has any extended study been made of these glands, or a full comprehension of their importance penetrated the consciousness of the practicing urologist. It is in French literature then, that we must seek for enlightenment concerning both the normal and pathological states of these small structures, and upon what French surgeons have already achieved that we must base our own endeavors to understand and treat the various morbid states to which they are so frequently subject.

EMBRYOLOGY OF COWPER'S GLANDS.

Cowper's glands, according to Hertwig,[12] arise from two symmetrical diverticula originating in the lower segment of the uro-genital sinus. From sections made from embryos in the third month of fetal development, Hogge[13] observed little swellings in the lining of the uro-genital sinus which appeared to be forerunners of the first glandular buds,

but it was not until the fetus had attained a length of approximately 6 cm., at an age between three and a half and four months, that the bulbo-urethral glands actually appeared in the form of small lateral buddings directed toward the rudimentary formation of the urethral bulb. According to Lichtenberg,[17] Cowper's glands "probably originate," for he never had the opportunity to observe their very first appearance, "at the end of the second month of intra-uterine life, as solid bud-like proliferations of the epithelium of the seminal canal." In the specimens which he examined, which had attained a length of 48 mm., the glands were already in their typical position, in the wall of the seminal canal. He mentions that there are frequently two on each side, or one on one side and two on the other. These epithelial buds are from the first embedded in the firm mesodermal tissue which goes to make up the corpus cavernosum of the urethra, thence gradually extending in a direction almost parallel to the seminal canal, until they attain the less compact mesodermal tissue which lies between the seminal canal and the rectum. As they are much constricted by their passage through the relatively unyielding tissue, but are able to expand as they approach the rectal wall, each gland shows an intrabulbar portion with only a few short and ill-developed side-branches, while the extrabulbar portion will be well-equipped with branches much larger and wider than those of the first section. Lichtenberg observed that the side-branches appeared immediately after the original epithelial buds, and that lumina developed in the main stem and primary branches in embryos no more than 65 mm. in length. The transformation of the original epithelium into an epithelium peculiar to glands takes place by the time the fetus has attained a length of 120 mm., so that by that time, the structure can be designated as a "glandular stem tubule."

At term, or just before it, Hogge considered that Cowper's glands had acquired their distinctive structure, certain of their histological characteristics even indicating that for some time before birth they have been elaborating their peculiar secretion. Although in the infant these glands continue to increase in size, their development is slow when compared with that of the tissues by which they are surrounded, being especially disproportionate to the enlargement and definite progress of the branches of the ischio-pubis. Thus, in the fetus and the new-born, Cowper's glands are of far greater importance in their relation to adjacent structures, than they are in the fully-developed adult.

Number and Classification.—In Méry's original account, he describes only two glands lying behind the urethral bulb, but Cowper told of a third, which he located in the median line at the intersection of the bulb and the membranous urethra. Later anatomists, notably Littré, Lieutaud and Morgagni, confirmed Cowper's finding of a third gland, but regarded its occurrence as sufficiently irregular to warrant its being regarded as accessory and more or less anomalous.

Gübler found that accessory glands were frequently present in the deep spongy tissue, and on either side of the excretory ducts of the true Cowper's glands, but Lebreton, after a large number of dissections, concluded that the existence of only two definite glands can be established. Hogge, however, whose study was primarily upon the muscles of the perineum and pelvic diaphragm, made a vast number of sections of the fetus near or at term, and in recording the results of his investigations classified the bulbo-urethral glands as of two distinct types: (1) Two larger and higher lying *diaphragmatic glands*, so-called because they are within the uro-genital diaphragm, and (2) two smaller accessory *bulbar glands*, made up of lobules lying deep in the spongy tissue of the bulb. These last-named are aggregations of lobules which are not infrequently blended so that only a single accessory gland is evident. Embryologically diaphragmatic and bulbar glands have a common origin; "they arise by a budding out of the uro-genital tissue which has its origin at the bottom of the spongy urethra. Histologically they are identical, and all their excretory products find an outlet in the two ducts which open upon the lower wall of the spongy urethra. The bulbar lobules are more disseminated than those which are situated higher in the uro-genital diaphragm; neither are they as completely united as those of the diaphragmatic glands."

The *diaphragmatic glands* lie in the thickness of the uro-genital diaphragm, on either side the median line, separated by an antero-inferior prolongation of the centrum; their posterior portions almost touch. Hogge found that they are surrounded by fibers from the uro-genital sphincter, which furnishes them with a strong contractile envelope with openings only at two points, internally at the prolongation of the centrum, and on their inferior surfaces, where they are either attached to the superior wall of the bulbous urethra, or else continuous in the bulb with the bulbar lobe which corresponds to these glands.

The *bulbar glands* are made up of those tubules which lie on either side beneath the uro-genital diaphragm in the spongy tissue of the urethra, or even in the intrabulbar median raphé. Sometimes these lobules attain a size sufficient to rise to the entire height of the bulb. These lobules are the *accessory glandules* observed by Jarjavay, Gübler and others, who however, regarded them as more or less inconstant and anomalous, whereas Hogge considers them as a normal finding, and of great pathological and surgical importance. Motz and Bartrina[19] also emphasize their importance in relation to perineal suppurations and chronic urethritis.

The diaphragmatic glands of Hogge therefore, correspond to what are commonly referred to as Cowper's glands, while for his bulbar glands there is no more definite equivalent than "accessory glands of the spongy urethra," "supernumerary urethral glands," or "mucous glands of the anterior urethra."

Definition.—Cowper's glands may therefore, be defined as mucous glands annexed to the uro-genital canal, being usually two in number,

lying in the thickness of the muscles of the uro-genital diaphragm, or between the fibers of the compressor urethræ, opening through two long excretory channels on each side the median line of the urethra upon the lower surface of the bulbar portion.

ANATOMY OF COWPER'S GLANDS.

Structure.—Most anatomists report Cowper's glands as acinous, made up of grape-like clusters of lobules, the walls of which are formed by a single row of pyramidal cells. The collecting tubules of these structures pour their accumulated secretions into a common excretory duct which, before emptying its contents into the urethra, travels for a considerable distance between the urethral mucosa and the spongy tissue of the bulb. Its course is somewhat sinuous, and all observers agree in describing a dilatation of the ampulla in that portion of the canal nearest its point of emergence from the gland. Luys[18] gives the average length of the excretory canal as 30 to 40 mm., but opinions vary greatly, so that one is led to believe that the length can only be roughly approximated, and that individual variation must be wide.

The canals have a lining of basal cell epithelium, usually disposed in a single layer. In the main excretory channel the epithelium in the region of the urethra appears stratified. The lobules which are united to make up the main lobes are held in place by means of connective tissue containing smooth, stratified and elastic muscle fibers.

Secretion.—Cowper's glands secrete a transparent viscous fluid, containing so much albumen as to give it an appearance like white of egg. This can often be detected as a clear drop at the meatus on sexual excitement.[25]

Location and Size.—The glands of Cowper appear to the eye as slightly lobulated bodies of a reddish color lying on either side of the median line of the urethra, embedded in its floor between the laminæ of the deep perineal fascia, located in the angle formed by the junction of the lower surface of the bulb and the upper surface of the membranous urethra. *The upper surfaces* of these glands thus lie directly beneath the deep layers of the perineal aponeurosis, separated in front by the terminal portion of the bulbar artery, which is occasionally reinforced at this point by a thin layer of muscular fibers. Ordinarily the bulb extends so far forward as to cover the glands completely, although in cases where they are exceptionally large, they will jut out somewhat from beneath it. *The lower surfaces* of the glands are in direct contact with the muscle plane forming the floor of the urethra, arising from the sphincter urethræ membranaceæ. They lie parallel to the inferior lateral wall of the urethra, from which however, they are more or less separated, sometimes being found immediately adjoining it, so as to be practically sessile; or again, 6 or 7 mm. from it, in those cases where the glands are large or equipped with extra long excretory ducts.

The *external borders* touch the origin of the bulbar artery in the angle where the aponeurotic and muscular surfaces come together. The distance between the *internal borders* of the two glands varies as much as $1\frac{1}{2}$ cm. in different subjects, and in some dissections, the two inner edges have been found to be joined together by a tiny bridge of glandular tissue. *The anterior pole* of each gland usually lies in front of the bulbar artery, and from this point, in most specimens, the excretory channel takes its rise; while *the posterior pole*, which is occasionally bifid, impinges upon the posterior border of the median perineal aponeurosis and comes into relation with the apex of the prostate, here being surrounded by the lowest fibers of the compressor urethræ muscle.[15]

The different anatomists who have described these glands are far from being in accord as to their size. Most of them, employing what we may term a "vegetable system" of measurement, we find comparing their size to that of lentils, peas, beans and all the way up to hazel-nut. Frequently one gland is reported larger than its fellow, and as has already been noted, it is not uncommon to find an observation where they are both reported as on one side, or one on one side and two on the other, accounts which are difficult to make conform with the findings of Hogge. Lebreton found the left gland present in every dissection but in a number of his subjects the right was wholly lacking, and when both were present, the left was always the larger. Thus he concluded that the well-established observation that cowperitis is always left-sided, can be explained on purely anatomical grounds.

As has already been noted, the various lobules which go to make up the main glands, as well as those composing the more or less inconstant accessory glands, are all provided with excretory channels, so that, following Hogge's differentiation, we must bear in mind that the excretory system is in two divisions; that of the diaphragmatic glands and that of the bulbar glands; all, however, finding their final outlet through the two main channels which communicate with the urethra. Hogge described the excretory canals as lying upon the lower internal surface of each gland, constituting its hilum. All these excretory channels converge before they reach the median line which is occupied by a prolongation of the centrum, which farther down merges itself into the intra-bulbar septum. These excretory canals all pursue an upward course across the superior surface of the bulb, behind the bulbar artery. Ordinarily conduits from the diaphragmatic glands of Cowper, to the number of two or three, can be observed traversing that section of the spongy tissue which lies between the lower surface of the urogenital diaphragm and the inferior wall of the urethra. These conduits anastomose on either side to form a larger canal, which, in its turn, receives the contents of the collecting tubules of the bulbar gland and advances into the space lying between the spongy tissue and the urethral mucosa, through which it pursues a relatively long course until it finally gains entrance to the lumen of the urethra.

As the bulbar lobules are often separated by a considerable thickness of spongy tissue, their secreting ducts do not anastomose as do those of the lobules making up Cowper's glands proper. Instead each tiny lobule empties its secretions directly into the large channel which carries the products of the diaphragmatic glands out to the urethra.

Bloodvessels.—In the normally developed bulbo-urethral gland, according to Lebreton, the bulbar artery before plunging into the bulb practically always crosses the superficial aspect of the gland; most frequently about one-third of the way down, where sometimes the investigator may see a tiny sulcus, running obliquely forward and inward, plowed out by the passage of the artery. Again, the artery may lie further forward, so that it crosses not the gland itself, but its excretory canal. But in either event, the important point for the surgeon to bear in mind is the practically constant relation between the bulbar artery and the superficial aspect of the gland.

The veins leading out from the bulb run further forward and deeper than the artery, so that their relations with the gland are much less intimate.

FUNCTION OF COWPER'S GLANDS.

While histologically they are mucous glands, their structure being the same as that of the other urethral glands, functionally Cowper's glands should be enumerated among the genital organs. During the sexual act from the initial erection until the orgasm, they are active in contributing their peculiar secretion to the stream composed of the secretions of the other genital glands, which combine to form the seminal fluid. The particular property of the secretion of Cowper's glands appears to be the lubrication of the urethra. Provided with collectors, situated in the muscular diaphragm, infiltrated with muscular fibers and innervated by rami of the genital nerves, those glands play a by no means negligible part in the sexual act. At the moment of ejaculation they undergo rhythmic contractions and expel their collected secretions in a manner analogous to that of the more important genital organs.[22]

DISEASES OF COWPER'S GLANDS.

Acute Cowperitis.—The most common cause of inflammation of Cowper's glands is gonococcal infection, cowperitis appearing most often as a complication of gonococcal urethritis. It is a very general observation however, that it is a relatively rare affection in view of the wide prevalence of gonorrhea. It was suggested by Motz and Bartrina that in those individuals whose excretory ducts were long, there was a certain measure of protection from the attacks of the organisms infecting the urethra. If these canals were uniformly short, Cowper's glands would participate in the inflammatory condition as often as does the prostate. On the other hand many an intractable chronic

urethritis would seem to be due to continual reinfection of the urethra by organisms which have penetrated as far as the cul-de-sacs of Cowper's glands.

Examination.—Unless there is frank abscess formation, ordinary palpation will fail to reveal inflammation of these glands, and even palpating over a sound will not give complete information if the lesion happens to be deep in the perineum. Bidigital palpation of the perineum offers the best chance of diagnosis. The patient should be placed on his back, the thighs flexed, with the heels together and the knees separated, and the buttocks elevated upon a hard cushion or sand-bag. The examiner's index finger is introduced into the anus, palmar surface upward, and so inclined as to lie above the sphincter region, pressing down upon the rectal wall. The thumb, outside upon the perineum, gradually compresses the tissues just outside the median line, advancing along the bulb with as deep pressure as possible, to the bottom of the groove formed by the bulb within and the corpus cavernosum without. This bidigital palpation will permit the examiner to determine the presence of a small nodular mass, the size of a hazel-nut or a large pea, attached to the deep lateral wall of the urethra, which is Cowper's gland, much increased in size. This procedure must of course, be carried out on both sides of the urethra, and should be a routine part of the examination of all cases of intractable urethritis.[22]

The sight of a definite external swelling on one side of the bulb should serve to enable even a tyro to make a diagnosis of cowperitis. But often the swelling will not be definite and will appear so diffuse as to suggest a urinary abscess, thus making diagnosis a more complicated procedure.

According to Luys, it is by no means rare to find a urinary abscess following upon a cowperitis, and such an abscess is often, in the early stage, localized upon one side of the urethra, although later it will attain the median line and assume those peculiar characteristics which serve to differentiate it. There is less likelihood of confusion with an abscess of the anal margin, as this will lie further back and extend to a greater distance on either side of the anus.

Cowperitis is a relatively late complication of gonorrheal urethritis. Most authors do not mention its occurrence earlier than the third week. It may appear spontaneously, due to the general progress of the infection into the deeper tissues, or it may be "lighted up" by trauma, violent coitus, the passage of instruments, or too vigorous exercise, such as horseback-riding or bicycling. The glandular tissues are thus rendered less resistant to the invasion of the infecting organisms.

Symptoms.—The first indication of the involvement of Cowper's glands in the course of a urethritis is pain of varying character and intensity. Beginning with no more than a sense of weight in the perineum, it rapidly becomes severe and lacinating, the patient usually indicating its origin at a point to the right of the perineal raphé, whence it radiates toward the anus, the scrotum and the inside of the

thigh. The slightest pressure intensifies it, palpation being usually unbearable, and walking, coughing, or the pressure of the clothing, causing acute distress. It will be recalled that Cowper's glands lie between two folds of the triangular ligament, surrounded by the deep perineal fascia. These structures are very resistant and unyielding, so that the swelling of the inflamed gland produces great tension which accounts for the intensity of the pain. As it is the function of the transverse fibers of the compressor urethræ muscle to contract when the bladder is evacuated, so as to expel the last few drops of urine, the act of micturition becomes intensely painful, and urination is occasionally hindered by the mechanical pressure if the swelling of the gland is very marked. In the same way also, by backward pressure toward the rectum, defecation may be made difficult and painful.

The swelling is usually left-sided, as has been already noted; even if two fully-developed glands are present it is rare for both to become involved. Fuller states in his text-book that he has never seen a case of bilateral involvement, and all authorities agree that it is very unusual. Probably also, in the bilateral cases one gland, usually the left, is affected before the other.

As the inflammation increases a visible mass appears in the perineum, for owing to the relatively great length of the excretory ducts, any pus which forms in the gland is unlikely to be discharged into the urethra. The mass commonly appears just in front of the anus, gradually spreading out toward the base of the scrotum, so that at times it may easily be confused with a tumor arising from the testicle or its adnexa. Above, the advance of the swelling is limited by the perino-crural fold which it never passes; but toward the median line it frequently extends over the raphé, encroaching more or less upon the unaffected side. As soon as the periglandular tissues are involved the skin of the perineum becomes red and edematous, while chills, rise of temperature, leukocytosis and the other indications of abscess formation, are in evidence.

It is sometimes possible to express the contents of the gland before abscess formation has begun, according to the method of Luys. After the patient has urinated, the bladder is filled with boric acid solution. The inflamed gland is now massaged as vigorously as the patient's condition will permit, care being exercised not to touch the prostate, after which the bladder content is passed into several glasses. The first of these glasses should contain the inflammatory products of the massaged gland, which can, after being centrifugated, be carefully examined under the microscope. Luys warns, however, that this method is not invariably successful. Sometimes the most vigorous massage will fail to empty the gland, and only succeed in causing the patient extreme pain. This is usually because the ducts are obstructed, and in this event the surgeon's only recourse will be an attempt to make them patent by means of urethral dilatation. This is by no means an easy matter, for as Doble[5] has remarked, evidences of

inflammation in Cowper's glands are frequently very difficult to postulate in the urethra. Even in cases where the glands are known to be infected, it is of the rarest occurrence to see pus coming from the mouths of the ducts. Unless abscesses of these ducts had been found, the urethroscopist would certainly doubt the possibility of there being such a disease as cowperitis. A congenital cystic condition may be found. The tip of a bougie may be held up and a diagnosis of stricture made. Only urethroscopic examination can now clear up the diagnosis. If the gland cannot be evacuated by way of the urethra, the only resort is perineal incision.

Chronic Cowperitis.—A state of chronic inflammation in Cowper's glands doubtless exists in many cases where it is wholly unsuspected: Urethral lesions of long standing, chronic urethritis, strictures of greater or less extent which by a "damming-back process" serve continually to relight the inflammation in these glands,[24] any or all of these pathological conditions may serve to induce a chronic state of inflammation which reacts upon the entire organism and yet remains unrecognized unless it is exacerbated to the point of suppuration and possibly, fistula formation.

The importance of these glandular inflammations in connection with the treatment of chronic urethritis can hardly be over-estimated. In the words of Pasteau, "Many an intractable chronic gonorrheal urethritis has its focus of reinfection in a chronic cowperitis, which has passed unperceived, and for which a systematic search should always be made."

It was contended by Bartrina and Motz that most periurethral suppurations were due to abscess formation in Littré's glands and those of the membranous urethra, in Cowper's glands, or in those lying within the bulb, the bulbar glands of Hogge. These authors showed that such suppurations may become a point of departure for urinary abscesses or infiltrations of urine; moreover, even when the process did not advance to abscess formation, there might be a constant state of inflammation existent in the glands which would keep alive for many years the chronic urethritis to which certain patients were subject. Haas,[9] commenting on their theory that a long excretory canal probably protected Cowper's glands in many cases from participating in an inflammation of the urethra, remarks that by the same token, once the canals and their glands do become infected, this very length of the excretory ducts would account for the tenacity with which the infection maintain its hold, despite all efforts to dislodge it.

Chronic cowperitis occurring in the course of a gonorrheal urethritis, is either directly due to gonococcic infection, or to the invasion of the already inflamed areas by the organisms. Just as it is frequently impossible to demonstrate gonococci in a case of urethritis of many months' standing, a cowperitis capable of continually reinfecting the urethra will often show no Neisserian diplococci, presenting instead a much varied mixed infection. It is only when the inflammatory

process of the gonococal infection has reached the posterior urethra that Cowper's glands become involved, the inflammation progressing by continuity and advancing down the excretory ducts, which offers an explanation of why cowperitis is always a late complication of gonorrheal urethritis. Once established there, we frequently see what Pasteau has described as one of those glandular affections likely to become chronic at the first onset (*chroniques d'emblee*) and presenting so few symptoms as often to pass completely unrecognized. Such a condition may follow an acute attack of cowperitis, even if it has not advanced to the suppurative stage and has evidenced little or no inflammatory reaction. The manifestations of prostatitis, of inflammation of the vesicles or of the glands of Littré, are quickly recognized and generally amenable to treatment, but in the great majority of cases the inflamed state of Cowper's glands passes unnoticed because it is difficult to discover, and is out of reach of the therapeutic methods usually employed. Practically the only sign which can be detected without urethroscopic examination is the chance palpation of a much enlarged gland.[9]

Fistula Formation.—The pain and marked external swelling caused by suppuration in either of Cowper's glands, usually bring the patient to the physician before the abscess has opportunity to "point," and it is the experience of practically all that such tumors, if promptly incised, heal without any untoward complications. But in those cases where the abscess is evacuated without surgical assistance an intractable fistula is likely to form, which may cause much trouble to those who attempt to obliterate it. Such an instance is cited by Henri Reynès, whose patient had suffered several attacks of gonorrhea and finally observed a small tumor in the perineal region, which opened spontaneously, evacuated and apparently healed. After a short time, however, the wound reopened, which was eventually followed by fistula formation; the fistula being on the *right* side, between the anus and the scrotum, about 3 cm. from the median line. Reynès explored the fistula and found it led directly to the right Cowper's gland, being very evidently the outlet of a chronic inflammation of long standing. There was no stricture in the urethra and the mucosa of the urethral canal itself appeared normal. Lebreton believes that the reason these fistulæ are so resistant to treatment is because the glandular secretions pass through them instead of finding their normal outlet in the urethra, and that this could only occur when the excretory channel is occluded, or has been cut, as might happen in incising an abscess, or possibly has been destroyed by the suppurative process.

Treatment of Fistula.—Under such conditions it is not likely that the fistula can be closed except by extirpation of the diseased gland. If the excretory canal can be made patent, wide resection of the fistula may serve, but the condition is one likely to put a severe tax upon the endurance of both physician and patient.

Frequency of Chronic Cowperitis. Not many of these cases of fistula are likely to occur in the practice of any one physician, but the probability of his being called upon to evacuate latent cowperitis is much greater than he would be led to suppose by a perusal of recent textbooks.[2] Some two years ago Leszczynski[16] examined 44 cadavers coming in for routine dissection at the University of Lwow, rejecting only those specimens which he deemed likely to have undergone extensive postmortem alterations. His results caused him "veritable stupefaction." Having undertaken the research merely with the hope of proving that there is such a pathological entity as chronic cowperitis, he found that in his 44 subjects, only 25, or 56.8 per cent, had normal Cowper's glands. Even omitting 1 case of cystic degeneration, and 2 of senile atrophy, there remained 16, or 36.36 per cent, who presented evidence of healed or active inflammatory lesions. "One subject in 5 was, at the time of his death, suffering from an uncured cowperitis."

Tuberculosis of Cowper's Glands.—Infection of Cowper's glands by the tubercle bacillus is even more rare than the same occurrence in the urethra. The earliest description we have encountered is that of Englisch[8] published in 1891. Eleven years later Hartmann and Lécène[11] reported 2 cases, the descriptions of which were accompanied by careful pathological records. The first of their cases they admitted as open to question as to its purely glandular origin, but the second gave, in their opinion, absolute proof that the tubercle bacillus can primarily invade Cowper's gland. The gland was removed entire during surgical treatment of gonorrhea, and on microscopic examination, tubercle bacilli were observed, together with the characteristic cell-formation of tubercular inflammation. As the entire specimen had been fixed previous to examination, no guinea-pig inoculation could be practiced.

Shortly after, Hallé and Motz[10] described 6 cases of tuberculous cowperitis which they had encountered in a study of urethral tuberculosis. They observed two forms, the caseated cysts of long-standing, limited to the gland itself, and a form of intracapsular cystic tuberculous caseation. In 2 of their cases the lesion had advanced toward the urethra, following along the excretory canal. At the center of the bulb, upon the floor of the urethra, there was a tuberculous nodule which was caseous and cavitated, replacing the anterior accessory lobule of the gland, the infiltration following the line of the excretory duct to its point of opening into the urethra. These authors also examined Guyon's collection of specimens of genito-urinary tuberculosis, and found among them 10 examples of infection of Cowper's glands. A number of types were represented; massive caseous infiltration of the gland; caseous cystic transformation; abscess of the bulbo-urethral triangle originating in Cowper's gland, and intrabulbar cavitation. They concluded that "regarded from the anatomo-pathological viewpoint, it is a frequent lesion."

Lowered Resistance Necessary for Infection. Perusal of the rather meager literature upon the subject seems to indicate that tuberculosis of Cowper's glands probably occurs most often as an extension of a tubercular process originating elsewhere in the genito-urinary canal, which is carried to the glands by infected urine. It is doubtful however, if the bacilli could find entrance to a healthy excretory canal, or be retained in uninjured glandular tissue long enough to gain a foothold. It is only when the resistance of the tissues has been lowered by previous inflammation that the tubercle bacilli find a soil suitable for their propagation. Some writers, notably Hallé and Motz,[10] think infection by the blood stream the most probable mode of conveyance, but this is particularly in those cases where there are isolated lesions in the erectile sheath, having no direct continuity with those in the mucosa. Where tubercular lesions are found both in Cowper's glands proper and the bulbar lobes, it is quite possible that we are witnessing both modes of infection. But in either case, it remains probable that an individual who has suffered a cowperitis in the course of a gonorrheal attack is thereby rendered more susceptible to tuberculosis of these glands, should they be exposed to infection.[15]

Primary Tuberculosis of Cowper's Glands.—A case of apparent primary tuberculosis of Cowper's gland has recently been reported by Papin and Vafiadis.[20] The patient was aged forty-three years and denied all venereal infection. Six years previously he had suffered from a severe bronchitis, but had never had any pulmonary hemorrhages. About five years before he had first noticed a whitish discharge from the meatus, for which he was treated with permanganate, although no gonococci were demonstrated in the discharge at any time. Occasionally he had experienced severe pain in the perineum, sometimes so severe as to prevent him from sitting down, and about two years before a large abscess had formed above the right Cowper's gland from which a large quantity of pus was evacuated. A fistula had since remained at this point discharging a sero-purulent fluid, negative for gonococci. About this period, after a violent physical exertion, the patient experienced intense pain in both testicles followed by swelling of these glands, the right testicle never thereafter returning to its normal size. Another abscess soon formed in the perineum which discharged a great quantity of pus and left a fistula in the same manner as the first, so that when he was examined by the authors cited, the patient showed two fistulous openings above the right Cowper's gland, both discharging a sero-purulent exudate. The prostate and vesicles were normal to palpation.

The affected gland was extirpated and on section showed typical tubercular infiltration; the surrounding tissues were unaffected. A fistula persisted which was stubbornly resistant to all treatment, and roentgen-ray examination later showed pulmonary tuberculous lesions, the existence of which had never been suspected by either the patient

or his physicians; the cowperitis being the first recognized tubercular lesion.

Pathology.—Two forms of bulbo-urethral tuberculosis are distinguished by Hallé and Motz, whose classification has been followed by most of the more recent writers upon this subject.

1. Intercapsulary glandular tuberculosis, in three stages of evolution, massive infiltration, breaking down in the center, with cavity formation, and finally caseous cystic formation. The lesion may even progress to complete destruction of the gland without impairing the integrity of the surrounding capsule. The periglandular cellular tissue remains unaffected.

2. Diffuse glandular and periglandular tuberculosis; formation of a perineal "cold" abscess having its origin in Cowper's gland, below and behind the bulb, or again, from the sides or rear of the bulb, resulting in a perineal fistula.

Diagnosis.—Tubercular cowperitis is, of course, most likely to be found in those already suffering from other tubercular lesions, either of the lungs or elsewhere in the genito-urinary tract. If there is a history of gonorrhea, especially of more than one attack, it should be highly suggestive. If a painless chronic discharge is in evidence, bacteriological examination may be negative for gonococci and positive for tubercle bacilli, but in the majority of cases differentiation is not so simple. If a tumor forms in the perineum which has the characteristics of an acute cowperitis such a diagnosis is almost sure to be made, and it is only after the abscess is opened, either by Nature or the surgeon, that the persistence of an intractable fistula suggests the true nature of the affection, which microscopic examination will confirm. Fistula formation however, is not invariable. In all the cases cited by Hallé and Motz the tubercular process remained walled off, and in nearly all of them was found only at autopsy.

Treatment.—If discovered while the lesion is still restricted to the encapsulated gland, complete surgical extirpation offers the best hope of cure. Earlier treatment consisted in drainage, cauterization and antiseptic packing of existing cavities, but the results were not such as to justify the employment of these measures at the present day. In most cases the patient's general systemic condition will be such as to overshadow the lesions in Cowper's glands, and their treatment will have to be subordinated to that decided upon as best suiting the conditions elsewhere in the genito-urinary tract.

RETENTION CYSTS.

Like other affections of Cowper's glands, retention cysts probably exist unrecognized in the majority of instances, and the paucity of literature upon the subject should not be taken as an indication of the infrequent occurrence of the condition.

In a now forgotten German periodical, published in the interest of

the "naturalist and physician," is the report by Englisch[7] of a case of retention cyst of the excretory duct, in the introduction to which he briefly reviews four earlier reports of similar cases, all he was able to discover in the literature, although Morgagni had made mention of the possible existence of obstruction in the excretory ducts of the bulbo-urethral glands which could lead to cyst formation.

In making a postmortem examination of a subject who had died after complete urinary retention for a period of four days, Forestus observed a tumor in the urethra which blocked its lumen, and upon further examination this proved to be a cyst arising from the excretory duct of Cowper's gland, which was filled with its characteristic secretion. Terraneus (1729) examined, presumably postmortem, a boy aged about fourteen years, who had from infancy suffered from urinary troubles which necessitated frequent catheterization. He found in the region of the accelerator urinæ a pyriform sac which completely occluded the urethra, incision of which evacuated a mucoid fluid. When probed the cavity was found to extend to the "glandula agglomerata," explained as a designation for Cowper's gland, having its origin in the excretory duct on the left side. Göbler, inspecting a fetus, encountered an obstacle to catheterization which proved on dissection to be a submucous serous cyst about the size of a barley-corn, embedded in the spongy tissue of the bulb. It was evidently a dilatation of the excretory duct of the left Cowper's gland. The bladder of the fetus was distended with turbid urine. The walls of the cyst did not collapse when incised. Berger, whose case is reported by Couillard, examined a patient who had had a mild gonorrhea ten years previously. Six years later a tumor had appeared in the perineum 2 or 3 cm. in front of the anus, which gradually increased in size, while there was occasional pain after micturition, although no diminution of the volume or force of the urinary stream. The tumor eventually broke down and suppurated, but always refilled. When incised by Berger it gathered once more and the patient was directed to appear for operation, but as he never did so, the case rested upon the presumptive evidence alone. Reference to Couillard's original article[4] gives the impression that this was a case of tuberculosis rather than cystic formation. He states that after increasing in size for about two years the tumor became inflamed and finally opened spontaneously discharging an odorless, slightly sangulant, somewhat viscid fluid. The external swelling now decreased but a mass the size of a hazel-nut was still palpable underneath. A fistula developed and from time to time a small quantity of fluid would be discharged, these exudations having a very evident connection with the act of coition. Thereafter the tumor always regained its normal size.

In Englisch's personal case a man, aged thirty-seven years, came under observation because of retention of urine. In the urethra at the bulbo-membranous junction were observed two pear-shaped sacs, about 8 cm. long by 1 cm. wide, lying on either side the septum

which was very thin at the ends. The cysts had displaced the spongy tissue of the bulb sufficiently to occlude the lumen of the urethra. Posteriorly they communicated with the excretory ducts of Cowper's glands, of which they appeared to be dilatations. The sacs, which had no connection with each other, contained a yellowish mucilaginous fluid which showed no formed elements.

A detailed account of the cysts which may arise in Cowper's glands was published by Elbogen[6] in 1886. He was inclined to believe that when found in adults their pathological significance was not very great, that they probably often existed without producing any symptoms, and it was only in exceptional cases that they caused retention of urine and drew attention to their presence. He found cysts in 2.3 per cent of the males upon whom he had performed autopsies, and made notes of 17 cases which he had observed postmortem. It is reasonable to suppose that even in some cases where a cyst attains a size sufficient to obstruct the urinary stream, efforts to relieve the obstruction by the passage of a catheter might rupture it, so that its presence would not be detected. He notes, however, that when they occur in young children, the effects are likely to be much more serious, in one case at least, causing retention of urine which eventuated in hypertropy of the bladder and hydronephrosis. This may very well be an etiological factor in congenital hydronephrosis which is usually ignored. Elbogen's investigations led him to conclude that these cysts may be present at any time of life, as he found them in a child, aged seven days, and a man, aged sixty years. As regards location, he observed them in 17 instances, 7 times in the right duct, 6 times on the left, and in 4 cases, in both right and left ducts. They were usually oval or pyriform in shape, although he observed one that was distinctly cylindrical, and another that "resembled a biscuit." The size varied greatly in different individuals, running from 1 to 4 cm. in width, with a length of from 5 to 9 cm. Etiologically these cysts may arise because the secretion of the glands becomes abnormally profuse, or more probably because inflammation of the urethra has blocked up the entrance through which the secretion is normally discharged; in the new-born there may be congenital occlusion of these orifices. Dilatation of the duct first occurs, followed later by the formation of a sac which is filled by the retained secretions. Histologically, the wall of the sac is found to be made up of connective tissue, with a lining of cylindrical epithelium. This epithelial lining was absent at the lower end of some of the cysts examined, its place being taken by a mucous substance in which the nuclei of epithelial cells is suspended.

A single case of Cowper's gland cyst is reported by Lebreton. The patient, aged fifty-five years, had had gonorrhea fourteen years before. For four years there had been a tumor in the perineum, accompanied by difficulty and frequency of micturition. This mass was several times incised and drained, but it always recurred, and finally when the

patient observed that pus and urine were being evacuated from the fistula, he decided to enter the hospital. The perineum was incised and the cavity curetted and packed with iodoform, with speedy cure.

The only American writer who has given the subject of these retention cysts any consideration, save bare mention in a few text-books, is Crouse of Texas[3] who published 2 cases in 1911, and made an excellent review of previous literature. His first patient was aged twenty-nine years, with a history of a specific urethritis five years before. Urethroscopic examination showed a large left-sided cyst in the bulbous urethra, which was diagnosed as a blennorrheal occlusion of Cowper's duct. The cyst was removed through the urethroscope and the duct injected every third day with silver nitrate solution. No gonococci could be demonstrated in the cyst content, but a smear from the urethra showed a few attenuated Neisser germs. The second patient, aged thirty-eight years, gave a history of gonorrhea eighteen months before with many subsequent recurrences, and admitted masturbation. Urethroscopic examination showed a large cyst in the bulbar portion of the urethra, oblong, pyriform and apparently cleft. Incision on the right side evacuated a large quantity of fluid, and when the field had been cleared another smaller cyst was observed on the left, which was also opened and emptied.

Treatment.—With the modern instruments now in the hands of every urologist the recognition and extirpation of retention cysts of Cowper's glands should present no difficulties. It should never be necessary to curette the cavity through a perineal incision, as the cyst can be removed from within the urethra by employing the proper technic, and only in those cases so neglected as to have already formed a perineal fistula when they first come under observation, will other measures be required. After the cyst is removed and the site injected with silver nitrate or other suitable agent, it is well to locate and dilate the excretory ducts if possible, thus guarding against recurrence of the obstruction below the orifice. Persistent recurrence of the cysts might call for removal of the entire gland, but this would prove true only in very exceptional cases.

MALIGNANCY OF COWPER'S GLANDS.

We have been able to find but one record of a malignant neoplasm of Cowper's glands which has been noted since the appearance of Lebreton's thesis. The three which this author collected are, in chronological order: That of Paquet and Herrmann[21] reported in 1884; of Piertrzikowski,[23] in 1885; and of Kocher,[14] 1886. These were all epithelial carcinomas, developed at the expense of the glandular acini. In the first and third cases, the structure of the neoplasm was somewhat modified in certain areas by the pressure of hyaline masses among the epithelial cells.

Etiology. The cause of malignant neoplasms arising in this region can only be guessed at, as in the case of the majority of such growths, wherever located. In one case there was a history of trauma, the patient having many years before fallen from a considerable height astride an iron bar, following which accident, he had always suffered more or less urinary disturbance. No possible etiological factors are mentioned in the other cases, but it is conceivable that previous urethral inflammation might furnish the irritating influence necessary to establish the neoplastic growth.

Clinical Course.—The first indication which the neoplasm gives of its existence appears in all cases to be a mass in the perineum between the anus and the bulb. The skin above the tumor shows no inflammation, and there are none of the constitutional symptoms which would point to a cowperitis or a tubercular process. Pain on defecation soon becomes very marked as the growth increases in size, but in none of the recorded cases was there interference with micturition or pathological evidence discernible by urinalysis. This is an important differential point, for malignancy of the urethra quickly causes marked disturbance of the urinary function. In no other neoplasm of the genito-urinary tract is pain present so early in the course of the disease, sitting and defecation especially soon becoming exceedingly distressing.

Prognosis.—The prognosis is poor, especially if the subject be young. Metastasis to the inguinal glands and elsewhere, occurs very early, and rapid recurrence is likely to follow extirpation.

Treatment.—Treatment so far as clinical observation goes can only be complete surgical excision at the earliest possible moment, with accompanying removal of all glands likely to have become infected. We have been unable to find any reports where radium has been employed under such conditions, but this therapy would seem to be well suited to application in these cases.

Rarity of these Neoplasm.—Since Lebreton's publication the only case of a neoplasm of Cowper's gland which we have been able to discover is that reported by Blanc and his co-workers[1] in 1910. But as this did not come to operation and there was no pathological report, the diagnosis rested upon clinical evidence only, so that it cannot properly be included among authenticated cases.

More extended observation upon Cowper's glands, both normal and pathological, is urgently needed, for the importance of these small structures in the very prevalent conditions of urethritis and its sequelæ, with which every urologist is only too familiar, has yet to be appreciated, and our present meager knowledge can be greatly augmented by careful clinical and histological observation.

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CHAPTER X.

THE FEMALE URETHRA.

EMBRYOLOGY OF THE FEMALE URETHRA.

As we have already seen, when the fetus has attained a length of about 11 mm. the primitive uro-genital sinus becomes differentiated, by a gradual process of elongation and constriction, into a dorsal vesico-urethral anlage and a phallic portion. This vesico-urethral section is thereafter gradually converted into the bladder and the prostatic and membraneous portions of the urethra of the male fetus; in the female fetus, the entire urethra develops here.

The separation of the bladder from the urethra comes about by a differentiation in cell structure; as a result of the rapid cell division which precedes the formation of new layers, the cells of the urethra become smaller and their nuclei lie closer together. This process makes the epithelium of the urethra have a darker appearance than does that of the bladder, the change in appearance being fully evident when the embryo has reached a length of from 25 to 30 mm.[12]

Sex differences being noticeable in embryos no older than eleven weeks, it is about this period that the female urethra takes its characteristic form. In the female the phallus lags in development and becomes the clitoris, with its homologous glans clitoris and prepucium. The shorter urethral groove never extends onto the glans as in the male.[2]

Histology.—A transverse section of the fully-developed female urethra shows it to be composed of two strata, an inner epithelial layer and an outer muscular tunic. The epithelial layer is usually of the squamous stratified type, although occasionally specimens are encountered which display transitional stratification, and rarely, the stratified cylindrical type will be seen. Beneath the epithelium is a fine connective tissue, and in sections cut near the meatus, papillæ will appear. The outer tunic is made up of unstriped muscle fibers, the inner fibers being circular and the outer ones longitudinal; the two types of muscle fibers being separated by considerable elastic tissue and the numerous veins which make up the *corpus cavernosum urethræ*. The sphincter externus, a bundle of striped muscle fibers, surrounds the urethral meatus.

Urethral Glands.—The most important glands of the urethra are known as Skene's glands, narrow canals running inward for a distance of from 0.5 to 3 cm. into the lateral posterior urethral wall, their origin being just within the orifice. They are lined with stratified

squamous epithelium, which at times, near their blind ends, is merely a single layer of cuboidal cells.[14] The other periurethral glands are mostly compound and racemose, opening by a single duct upon the urethral mucosa, the deepest portions being lined with columnar epithelium; near the meatus they are often dilated, forming visible crypts. Morphologically the periurethral glands are the homologue of the prostate in the male.

Urethral Mucosa.—The urethral mucosa lies in longitudinal folds, the largest of these folds occupying a position in the middle of the posterior wall, joined on either side by a parallel fold. The mucous glands, which are tubular and branching, are more numerous below, while the submucosa carries numerous vascular papillæ containing lymph nodes.[23] The veins of the corpus spongiosum urethræ which lie close to it, extend somewhat into the muscular coats.

The Sphincters.—The sphincters are described by Kelly and Burnam as: (1) Unstriped muscular coats, consisting of a thin outer and inner longitudinal and a thick middle circular stratum, continuous with the trigonal musculature above, and known as the *involuntary sphincter of the urethra*. The fibers are strongest near the bladder, becoming progressively thinner and ceasing altogether in the lower third of the urethra. (2) *The voluntary sphincter of the urethra*, is composed of bundles of striped muscle fibers, which surround the three unstriped muscle coats, but describe a definite ring only around the upper urethra; further down they merely make a semicircle at the front and terminate in the lateral vaginal wall. These fibers are the exact opposite of those of the involuntary sphincter, as they are strongest below, altogether ceasing as the bladder is approached.

ANATOMY OF THE FEMALE URETHRA.

The female urethra is notably shorter than the same structure in the male, being only from 2.5 to 3 cm. in length, about $1\frac{1}{2}$ inches, of a spindle-shape, slightly constricted between the meatus and the neck of the bladder,[9] but of very elastic consistency and considerable thickness, 10 to 12 mm. The longitudinal folds of the lining mucosa already mentioned, make it possible to distend the canal considerably without any injury.

Relation to Other Structures.—The general direction of the urethral canal in the female is downward and forward with a slight anterior curve about the lower border of the symphysis. In its lower two-thirds, it is closely related to the anterior vaginal wall, so that a single thick stratum of tissue is all that separates the lumen of the urethra from that of the vagina. In front and on either side the urethra borders on the pubic venous plexus, the corpora cavernosa of the clitoris and the vestibular bulbs, while it passes through the triangular ligament.

The Meatus. The meatus is a vertical slit about 5 mm. in diameter, lying between ridges which are more or less prominent in different individuals, these being usually designated as the urethral labia. Externally, the termination of the urethral canal appears as a straight rounded prominence, some 2 cm. below the clitoris, this elevation being known as the urethral papilla; upon its summit the urinary meatus opens.

ANOMALIES OF THE FEMALE URETHRA.

Malformations of the female urethra are even more uncommon than those observed in the male. Of hypospadias and epispadias as they are manifested in the female, some mention has already been made (page 122). Cases have been reported where the urethra was entirely absent, and in a few instances the urethra has been partially or completely doubled, but only a very few such abnormalities are on record in medical literature.

Double Urethra.—Double urethra in the female has been reported by Pean, Wolfer and Colzi[14] while Furst, is quoted by Herman[19] as having demonstrated a case of duplication of the female urethra where there was no accompanying malformation of the bladder, which was up to that time, the only uncontested instance on record.

The only recent account of this anomaly which has come to our attention is that of Dannreuther,[7] published in 1923. The patient was a woman, aged fifty years, who had been married for thirty-four years, though she had never been pregnant. She had never suffered from enuresis nor incontinence, but finally came under observation because of increasing frequency and pain in voiding. Just below the normal external urinary meatus "a small red excrescence" which "presented the appearance of a carbuncle and was exquisitely sensitive" was discovered. "A probe, pushed through a tiny slit in its center traversed a path upward, backward and to the right. When a cystoscope was introduced into the bladder, the probe was seen to emerge from a small aperture in the vesical wall, a little to the right and above the right ureteral orifice." The anomalous canal was lined with mucous membrane. Kidneys and ureters were normal, as were the external genitalia and the remaining pelvic organs.

Diverticulum of the Female Urethra.—While congenital diverticulum should be classed as a urethral anomaly, the acquired type is properly a pathological one, so that a discussion of this condition finds its logical place between the consideration of congenital anomalies and of those which have been induced by postnatal influences.

The *literature* concerning all forms of urethral diverticula in the female is decidedly scanty. In 1869, Priestley[33] published 3 cases under the impression that he had been dealing with disturbed sebaceous follicles, and Lawson Tait,[43] in 1876, and again in 1885 described 4 cases which he regarded as either congenital, like intestinal diverticula, or due to a union between the urethra and a cyst of pathological origin.

Other instances were made public by Hickinbotham,[20] Englisch, of Vienna, Gillette and a few others, but Amand Routh[38] the celebrated British gynecologist, writing in 1890 states that very few modern English text-books of gynecology make mention of these cases, and strange to say, neither Emmet nor Skene alludes to any other form of urethral dilatation than the simple urethrocele, although they enter largely into genito-urinary troubles. He adds that "as the etiology of these cases is so distinct from that of simple dilatation, it seems a pity that both should be grouped under the one word urethrocele." This distinction has not even yet been made clear, as in the most recent account of this condition in the female which we have been able to find,[30] these two terms are used interchangeably.

Etiology.—The few observers of this condition ascribe its existence to these general causes: It may be (1) congenital; (2) caused by rupture into the urethra of a preëxisting vaginal cyst of postnatal origin; or (3) due to trauma to the urethra during labor.

It can readily be appreciated that if any of the urethral glands become "plugged up" as a result of inflammation or otherwise, they may be quickly converted into retention cysts. Later suppuration and rupture may occur so that the cyst once more communicates with the urethra, and the inflammatory condition is chronically relighted by the irritating effects of the urine which continually finds its way into the cavity. As a certain portion of this urine is retained, the size of the pocket constantly increases by dilatation as well as inflammatory reaction.

Trauma incident to childbirth may very well be the starting-point for most of the cases of acquired diverticulum. Many of the earlier cases were reported as being first observed in connection with labor in multipara; that of Hickinbotham however, being a conspicuous exception, as the patient was but aged twenty-one years, and at term with her first child when originally seen. The urethral diverticulum was nevertheless, the outcome of an extremely difficult labor, as the cyst ruptured the tenth day postpartem. Yet it is perfectly possible for the cyst to have been congenitally present, only becoming manifest through the conditions arising during the pregnancy.

Urethral calculus, stricture, or perforation are other forms of trauma which may serve to produce diverticulum, but it is apparent that the injuries suffered during parturition are the most prominent causal factor we are likely to encounter. Neel's case, reported in 1918[27] is the most recent report we have been able to find. The patient was a primipara, but had reached the age of thirty-six years. When eight months pregnant a soft tumor mass was seen presenting at the vaginal orifice. This mass was about the size of a hen's egg; there was no tenderness, but pressure caused the escape of muco-purulent material from the urethra. Three weeks after delivery, cystoscopic examination showed the internal urethral orifice to be about twice natural size, gradually blended with the sacculation of the posterior urethral orifice. The lining membrane presented the same appearance as the

urethral mucosa. This description tallies very closely with that of Priestley, given almost half a century before.

Treatment.—These diverticula undoubtedly exist during an entire lifetime without producing any symptoms, and if discovered accidentally they are best left alone. When inflammation has set in, however, surgery offers the best chance of permanent relief. The cyst wall should be dissected out, and abundant opportunity for drainage afforded. Fistula formation should be avoided by every means possible, as it offers the chief difficulty here encountered by the surgeon, such fistulæ being peculiarly resistant to treatment.

Prolapse of the Female Urethra.—A slight eversion of the mucous membrane lining the urethra is not an unusual occurrence, so that it is a relatively common finding in women, especially in those who have borne a number of children. Actual prolapse, so complete that the projecting mucous membrane forms a protruding tumor at the urinary meatus, is, however, a decidedly rare condition, comparatively few instances of which have been reported.

Age.—It is mentioned by Keefe[22] that a review of published cases showed the youngest patient to be five days old and the oldest ninety-two years. Unlike most gynecological lesions it has its highest incidence at the extremes of life; little girls are the most frequent sufferers and next in order are women whose muscular tissues have been debilitated by extreme age. Only some 12 per cent of the cases occur between the ages of fifteen and forty years, that is, the child-bearing period.

Etiology.—For this reason, the contention of that eminent gynecologist, Thomas Addis Emmet, that urethral prolapse in the female is due entirely to injury inflicted upon the tissues of the vesical neck and laceration of the periurethral structures by the passage of the child's head during labor, is hardly upheld. Doubtless some of the cases are due to this cause, but it offers no explanation for many others. Simpson's[40] patient was a multipara, aged fifty-six years, who had suffered from constipation of a most persistent nature practically all her life, so that he believed that the constant straining undergone by the patient at stool and a degree of vesical tenesmus, combined with a relaxed state of the mucous membrane due to her general debility, may have favored if not altogether caused the condition. He considered the condition neuro-muscular, that the nervous mechanism controlling the detrusor urinæ muscle loses its normal balance and exerts too great a force on the normally loosely attached mucous membrane of the urethra, producing extrusion of this membrane. This results in partial paralysis of the urethral constrictor muscle and the muscular tonus is not regained until this membrane has been replaced and retained in position by operative or other means.

Symptoms.—A tumor protruding at the urinary meatus is the most constant symptom, for in some of the reported cases there was no pain nor discomfort, while others presented all the distressing accompani-

ments of a urethral caruncle. The tumor is usually dark red in color, much congested and very sensitive to palpation. It may easily be mistaken for a long-pedicled fibroid presenting at the vulva. Careful examination, which is usually possible only under anesthesia, will reveal the true state of affairs.

Treatment.—If the prolapse is complicated by cystitis, or the presence of a calculus, these should first of all receive attention. When only a slight degree of prolapse is present, the inflammation may be reduced by rest in bed and hot applications, after which reduction may be attempted, either manually, or by the cautious employment of a sound. The use of astringents to promote contraction of the tissues may be successful, but cauterization is not to be recommended, as the resulting scar-tissue may so reduce the lumen of the canal as to make subsequent relief of stricture imperative.

In a few cases the prolapsed membrane has been digitally replaced and has remained in position without further manipulation, but usually operative measures will be necessary. A catheter may be introduced into the canal, the prolapsed mucosa cut away with scissors, and the cut edges united by suturing all around the orifice.

Shortening of the constrictor muscles may be carried out, if it is possible to replace the prolapsed lining of the canal. Keefe recommends making a vertical incision through the mucous membrane, muscle and connective tissue at the lower end of the meatus, picking up the ends of the circular muscle fibers on either side with tenacula, passing a probe into the bladder and uniting the muscle ends tightly about the probe by means of chromic gut sutures.

Emmet's "Buttonhole" Method.—This procedure was compared by its originator to "the drawing of a portion of a handkerchief through a buttonhole in a coat." A sound is placed in the urethra and an incision made in the anterior wall of the vagina over the median section of the urinary canal, as far down as the redundant portion of the mucous membrane. The prolapsed section of mucous membrane is then drawn through the slit, traction being directed from before backward. While an assistant is holding up the excess of tissue, a large-sized sound should be introduced, so as to smooth out, as it were, the lining membrane, and carry it toward the neck of the bladder, and place the canal somewhat on the stretch. While this instrument is in place, the sutures should be introduced entirely through the flaps into the urethra, so as to transfix the lining membrane along the edges of the wound; the excess of tissue is then removed with a pair of scissors, and the opening closed.[11]

INFECTIONS OF THE FEMALE URETHRA.

Urethritis.—The most common cause of urethral inflammation in the female, as in the male, is gonorrhea, although several other infections, notably those due to colon bacilli and streptococci, or more rarely,

pneumococci or paratyphoid bacilli, are occasionally encountered. According to Kidd[24] such infections are usually descending and hematogenous in character; incapable of being communicated to the male partner in coitus, and due to a primary blood infection of the kidney. Less often, acute urethritis may be initiated by a septic catheter, a dirty pessary, or a dirty douche nozzle, and especially by the whirling douche, which is a popular and widely advertised, but highly dangerous toy.

Acute Gonorrheal Urethritis.—Acute gonorrheal urethritis in women runs a less severe course than in men, owing to the relative shortness and simplicity of the female urinary canal. The inflammation ordinarily originates close to the urinary meatus, thence spreading backward until it attains the region of the vesical trigone. Only exceptionally is the area beyond this point found to be infected. Gonococcal cystitis is very uncommon and ascending gonococcal pyelitis is practically unknown.

Symptoms.—The initial complaint is practically always that of a burning pain, experienced immediately after the patient begins to urinate, and ceasing as soon as all the urine has been voided. Kidd lays stress on the necessity of differentiating between urethritis induced by the gonococcus, and pyelocystitis due to colon bacillus infection. The pain in pyelocystitis is not felt as the patient begins to void but just at the first an intense pain comes on which lasts for some minutes after the act is finished. There is seldom any complaint of increased frequency of urination in gonococcal urethritis, as a contrast to the intense strangury and increased desire to micturate experienced in acute colon bacillus pyelitis. In acute gonorrheal urethritis there is seldom any fever, in acute pyelitis there is always fever.

Examination will show pus exuding from the urethral mucous membrane which will be inflamed, or even so prolapsed that it protrudes through the meatus. Pus is usually seen coming from this orifice, which makes it an easy matter to obtain a specimen for examination. Abscess formation in Skene's ducts and the paraurethral glands is very common, and if these have obtained any size they will on palpation give a sensation as of little tender, pea-like nodules, lying beneath the urethra or in its immediate neighborhood. The entire urethral region will be so exquisitely painful that the examiner will be obliged to proceed very carefully.

When the inspection of the canal is completed, the patient should be instructed to pass urine into two containers, in the first of which shreds, pus and the causative organism will appear, while the contents of the second may be clear, although if the inflammation has extended toward the vesical outlet, the second urine is likely to be clouded with pus. In acute urethritis the presence of the gonococcus is ordinarily so readily demonstrated by examination of the exudate that the use of the urethroscope is unnecessary, and should be dispensed with, save under conditions which are very exceptional, as it is impossible

to pass this instrument except under anesthesia, and the passage is sure to cause considerable trauma to the engorged and sensitive mucous membrane. The passage of a catheter is equally contraindicated, and if the pain on micturition is so great as to interfere with evacuation of the bladder, it is well to adopt the suggestion of Osgood, that the patient attempt to void while immersed in a hot sitz bath, or while hot applications are being made to the vulva and pubic region.

Unrecognized Gonorrhea.—If the inflammation is not very severe, a woman may pass through an acute gonorrhea in complete ignorance of the fact that she has been infected with a serious venereal disease. In the female a discharge from the genital region is of such frequent occurrence that its appearance seldom causes alarm, even in a woman who has never before had one. There is still a very general idea among the laity that one may "catch cold in the bladder," and if there chances to be a history of exposure to cold or wet, this will be confidently fixed upon as the exciting cause, and an infecting coitus which might otherwise be incriminated, wholly overlooked. If the symptoms are so mild as to cause but little inconvenience, the physician will very likely never be called upon, and in cases where the woman has reasons for wishing to conceal any irregularities in the physical state of the genito-urinary organs, she will avoid consulting him unless forced to it by extreme suffering. The gynecologist is not infrequently confronted by extensive pelvic lesions, the origin of which he is at a loss to account for, until perhaps some chance remark of the patient leads to the discovery of a preëxistent but unrecognized gonorrhea.

Chronic Gonorrheal Urethritis.—Chronic gonorrheal urethritis is often very difficult to detect, and if the patient has her own reasons for desiring to keep the knowledge of her condition a secret, she may be able to prevent even a competent examiner from making a correct diagnosis. This is one of the reasons for failure in the medical regulation of prostitutes, as those who are well-informed can, by passing a small amount of urine immediately prior to examination, wash away the incriminating evidence, and even if no efforts of this kind are made, the gonococci are frequently concealed beneath the folds of the mucosa, or under the epithelial lining of the urethral glands. In such cases only repeated examination, with intelligent use of the urethroscope, will serve to reveal those hidden foci of infection. However, as much moral or even legal significance often hangs upon the proof of possibility of infection, it is the duty of every practitioner who is called upon to examine a case where doubt exists, not to rest content until every diagnostic resource has been utilized.

Treatment.—In acute gonorrheal inflammation of the urethra, in the female, as in the male, though absolute rest in bed during the height of the infection is the ideal, it is, like most ideals, very seldom realized. Failing this, daily visits to the physician's office will have to serve. If menstruation supervenes during the acute stage absolute rest in bed should be regarded as imperative, as otherwise communication

of the infection to the Fallopian tubes is almost sure to occur, a most serious complication, often resulting in complete sterility. A bland non-irritating diet, such as has been already recommended (page 327) with an abundance of fluid so as to dilute the urine to as great an extent as possible, should be insisted upon under all conditions.

In the most acute stage continuous application of hot compresses or a sitz bath as hot as can be comfortably borne, offer considerable relief. A vaginal tampon, well soaked in some antiseptic, such as protargol, should be used constantly and renewed at least once a day.

Injections of potassium permanganate 1 to 2000 or 1 to 4000, or even 5000 in very acute cases have been found servicable by many authorities. Argyrol or other silver salt is also useful in this connection. The douche should be used at first four or five times in twenty-four hours. The temperature of the water should be about 105° F. Enough fluid should be used to fill the bladder, so that the water may be passed out again as a natural urination. This method is much to be preferred to the use of a catheter or any other instrument, as there is no danger of traumatizing the inflamed mucosa of the urethra.

Treatment of Chronic Urethritis.—If the method outlined does not serve to clean up the indications of infection within four weeks, the case must be regarded as chronic and more strenuous measures employed. Even when the urethral mucosa appears clear, there may be many hidden foci, which are actually active, and being continually exacerbated serve to render the patient infectious to any male with whom she has connection. The treatment in general is that which has been recommended for chronic urethritis in the male (page 326 *et seq.*). In addition, the urethral canal should be repeatedly dilated, gradually increasing the size of the instrument employed until one of 13 or 14 mm. diameter can be inserted.

Skenitis.—Skenitis, that is, inflammation of the ducts at the urethral orifice, is a frequent complication of urethritis in the female. Kelly suggests exposing the ducts by making "a little speculum" accomplished by bending two wire hairpins and clipping them in with artery forceps. In this way the condition of the ducts can be readily appreciated and appropriate treatment applied. Often evidence of the persistence of the gonococcal infection in these minute epithelial pockets can only be discovered after most searching examination, and unless an attempt is made to express the contents of these ducts, the fact that pus is being harbored there, may be entirely overlooked. Kidd says that when one or both of Skene's glands are infected, the lips of the meatus are usually everted and pouting, so that the floor of the urethra is slightly prolapsed, and the mouths of Skene's tubules, if inflamed, appear as red areolæ, in the center of which can be seen an opening which exudes pus, especially if the urethra is gently massaged from below.

Treatment. The infected glands may be washed out, using an improved syringe made of rubber tubing attached to a hypodermic

syringe, as devised by Kelly, by means of which a fraction of a drop of pure alcohol or carbolic acid may be conveyed to the duct.

A better method is to express the contents so far as possible, and then cauterize the duct thoroughly, using either nitrate of silver, or the electric cautery, the urethra being, of course, suitably anesthetized beforehand.

Non-Gonorrheal Urethritis.—Although Kelly and Burnam do not know of an acute urethritis which is not gonorrheal in character, and this appears to be the prevailing opinion, it is probable that many cases designated as "acute cystitis" are actually inflammations of the urethra, due to repeated irritations such as those of prolonged instrumentation, or the use of improperly sterilized instruments. A proper cystoscopic inspection of the bladder would show it to be normal. Such an acute inflammation is usually of but little consequence of itself alone, and responds readily to elimination of the cause and mild antiseptic treatment. It is, however, likely to become chronic, and to guard against this, active measures should be undertaken early and persisted in until positive proof of cure is readily obtainable.

Syphilis of the Female Urethra.—**Chancre.**—Chancre of the urethra is a far less frequent occurrence in the female than in the male. Fournier[13] in his study of syphilis in the female, gives a table of 249 cases showing the relative frequency with which chancres appear in different locations, and of these but 7 were found at the meatus or within the urethral canal. Tanton,[44] gathering the figures of several French authors arrived at a general proportion of 1 urethral chancre to every 39 elsewhere located. "In woman," he says, "meatal chancres are most often found at the lower edge of this orifice," a fact which Dassonville[8] attributes to the situation of this area nearest the external genitalia, so that it is more exposed to infection during coitus. Of intra-urethral chancres, the same author found the most common location to be in the anterior portion of the canal, which would naturally be expected. For infection to occur, it is evident that the causative organism must penetrate, not only the urinary canal itself, but also the tissues lining the canal. It can only accomplish this when the continuity of the lining mucosa has been broken, as would be likely in a patient who had previously suffered a gonorrheal urethritis, or had for any reason been subjected to repeated catheterization or other instrumentation.

When chancre occurs in the female urethra, it often assumes a crescent shape, the center occupying the lower wall of the meatus and the horns reaching the lateral walls. It presents a red, angry-looking erosion, covered with a scanty, sero-purulent exudate, and is surrounded by a wide zone of induration, the swelling often being so great as to partially occlude the meatal orifice. When the chancre is located exactly at the meatus, says Fournier, the urinary orifice will be puffed out, misshapen, gaping, red, bleeding easily on pressure, and displaying on palpation a very marked and characteristic

induration. Unless one has seen a number of similar lesions there is a good chance of being completely deceived as to the true character of the lesion, and to regard it as very probably malignant. The indurated area, surrounding the actual chancre at the meatus, often extends for some distance up the canal, and when making an examination, one should never omit to separate the labia and conduct a thorough search.

Endourethral chancre in both sexes has two prevailing symptoms, discharge and induration. On the appearance of the discharge a man will frequently seek medical advice believing that he has been infected with gonorrhea, but with women, such a manifestation is likely to cause little alarm, and no notice be taken of anything unusual until induration and, in some cases, a slight pain during micturition, directs attention to the urethra. In women an endourethral chancre will nearly always be found in the anterior portion of the canal, so that by bidigital palpation it is almost always possible to detect the induration. The left forefinger should be introduced into the canal until it comes in contact with the suburethral area, the right forefinger being applied to the meatus from in front backward, when the induration will be at once perceptible. Sometimes there will be a veritable cylinder of hardened tissue encircling the urethra like a cuff; again, the hardening will be confined to the lower section of the canal, in the region immediately adjacent to the lateral surfaces. There is usually an accompanying swelling of the inguinal glands. Any urethral chancre will be extremely slow in healing because of continual irritation by the passage of urine over its raw surface, and in women especially, these lesions often show themselves most resistant even to vigorous and prolonged antiluetic treatment.

Secondary and Tertiary Lesions.—Secondary and tertiary lesions of the urethra are both rare, although Tanton states that tertiary lesions are more often found in women than in men. Fournier considered that the majority of these gummatous syphilids of the urethra were secondary to lesions in adjacent tissues. He cites a case where one of these infiltrations was originally located on the right labia minora; it gradually advanced to the vaginal orifice, then little by little attained the vestibule, and finally reached the urethra; the urethral and periurethral tissues became deeply ulcerated and the canal gaped widely, showing a funnel-like aperture with no remaining vestige of a meatus. This author lays stress upon the extreme degree of induration always noticeable in the urethral tissues of the tertiary lesions, as well as in the initial chancre. Sometimes it would almost seem as if the meatus had been transformed into cartilage, and the whole picture is such as to strongly suggest malignancy. On inspection the tissues will appear dark red or of a grayish-yellow color, and will bleed upon the slightest pressure, all of these being symptoms which might very well be attributed to a malignant growth.

Differential Diagnosis.—Differential diagnosis, therefore, will have to be considered with some care. The age of the patient should have

consideration, for cancer of the urethra seldom develops in patients who are below the age of forty years, although one of those mentioned by Watson[48] was aged twenty-seven years. The development of a gumma is more rapid than that of a cancer; and the tendency of all tertiary syphilitic lesions is to form scar tissue, and not to become adherent to the underlying structures; usually also, there is but little discharge. Epithelioma, on the other hand, displays a thick projecting base, bleeds very easily and gives off a quantity of sanguinous offensive exudate. The differential diagnosis can be established by Wassermann tests upon the blood and spinal fluid, and by awaiting the effects of antiluetic treatment. But it must nevertheless be kept in mind that a positive Wassermann reaction means nothing more than that a patient has *had* syphilis, and that it is perfectly possible for a syphilitic to develop a malignant neoplasm, and in the existence of malignancy, so much time may be lost in awaiting the outcome of specific treatment that the neoplasm may advance beyond all hope of relief before it is finally recognized.

In his Paris thesis of 1909, Rougier[37] mentions a "chronic ulceration of the female urethra" which he classes among the teritiary lesions of syphilis. His description, apparently quoted from West's text-book, is of swelling of the anterior portion of the urinary canal and a peculiar hardness of the tissues about the meatus, rendering the outline of this orifice irregular. All the cases have been observed upon prostitutes, and although the suspicion in most cases that syphilis existed was, of course, very strong, in many the diagnosis was not definitely established. For this reason, Edmandson of Stockholm, denies the luetic etiology of the condition, being inclined rather to attribute it to the repeated irritations and trauma to which the genito-urinary organs of these women are continually subjected.

Tuberculosis of the Female Urethra.—Infection of the female urethra by the tubercle bacillus has been a few times reported, but it is apparently even more unusual than in the male (see page 330). A case was published in 1906 by Hartmann,[17] of Paris, whose patient, aged twenty-seven years, had experienced urinary difficulties for a period of about six years, pain and frequency, especially at night, being the most insistent symptoms. Although examination of the patient's chest was negative, there was a family history of tuberculosis, and the woman herself had at one time lost greatly in weight and been under treatment for "bronchitis;" each winter also, she suffered from frequent coughs. At operation, the urethra was found to be greatly hypertrophied and stenosed, so that it was thought best to excise the strictured portion and construct a new meatus, attaching the mucosa of the urethra below to that of the vagina, and laterally and above to that of the vestibule. Recovery from the operation was rapid, and thereafter the patient urinated normally, and had remained in excellent general health up to the time the report was made.

Histology.—The excised portion of the urethra proved to be enormously thickened and edematous, with greatly dilated vessels which were circumscribed by an area of embryonal cells. Here and there in the inflamed conjunctive tissue tubercular follicles were visible, these being composed mostly of round cells presenting all the characteristics of lymphocytes. In the midst of the lymphocytes were polyhedral cells with granular protoplasm, the nuclei being very large and having the general appearance of the so-called epitheliods. No typical giant cells were seen, but frequently two or three of the epithelial cells were united in such a way as to give the appearance of giant cells. These tubercular follicles seemed very like those of slow evolution observed in cutaneous and subcutaneous tuberculosis, seen frequently in lupus.

STRICTURE OF THE URETHRA IN WOMEN.

Although the title *Stricture of the Urethra* is found in the indices of practically all gynecologies and many general surgeries, the fact remains that the literature concerning the condition is decidedly meager, and on attempting to review it, one is impressed with the comparatively small amount of actual knowledge about urethral stricture in the female which is the common property of the medical fraternity.

Though the condition has been recognized for a full century, since it was in 1824 that Lisfranc first described it, yet the first case report, made by Earle,[10] of London, was not published until four years later, and in 1887, after a lapse of more than fifty years, Herman[18] could find no more than 29 cases which had been reported. Van der Warker[45] published an important paper in 1890, and Maurice Vilfoy made it the subject of the thesis which he presented at Paris in 1911,[47] but otherwise little has been written upon the subject.

Location.—While strictures have been observed in all parts of the urethra in the female, the most common locations are at the external orifice and in the anterior section. As a rule but one such contraction of the lumen will be found, but there are a few cases of multiple strictures on record.

Etiology and Pathology.—According to Wynne[51] strictures may be classified as traumatic, inflammatory, neoplastic, congenital, senile and unknown. Traumatic stricture is due to injury, most frequently that occurring during child-birth, although accidents such as scalding or burning, the application of caustics, operative trauma or occasionally the effects of masturbation, may be the causal factors. Injuries during child-birth involve the urethro-vaginal septum although not necessarily the entire wall of the urethra, as contracting bands in the anterior vaginal wall may compress the urethra dangerously. A tear through all the coats of the urethra may cause a complication of fistula with the stricture. Injuries due to accidents may be similar in effect to the injuries of child-birth, although in these cases the injury

may be confined to the external meatus, or may be intra-urethral. Cicatrices following burns and scalds are located at the external meatus.

Inflammatory conditions which may induce stricture of the urethra are gonorrhea, syphilis, tuberculosis or any other infection which is capable of causing ulceration of the vulva. Stevens[42] had the opportunity of observing a series of prostitutes confined in a special ward at the San Francisco County Hospital, and as practically all of these had at some time suffered from gonorrhea, the significance of this infection as a factor in the etiology of strictures could be determined. In fact, the meatal strictures occurring in prostitutes exceeded those found in clinic patients by 11 per cent and in private patients by 20 per cent. It is, therefore, apparent that Neisser infection is the most important etiological factor in strictures occurring at or just within the meatus. Gonorrheal urethritis usually induces a localized thickening of the urethral wall, while the lesions produced by syphilis are more likely to be a generalized induration and contraction of the canal as a whole. Neoplasms situated in the urethra will produce symptoms of stricture, but these are rare, and will be discussed in another paragraph. Congenital stenosis is occasionally found but this too, is an unusual condition. Wynne found that Blum and Fissiaux had each reported a case in which there were both persistent urachus and patent umbilicus. Jaboulay reported a case of pyelonephritis following congenital stricture; Johnson stated that this type is usually situated at the internal sphincter, or in the posterior third of the urethra. Skene also mentions the occurrence of congenital stricture.

Symptoms.—Our attention has been directed by Stevens to the sensitivity of the bladder to reflex influences, on account of which marked subjective symptoms are often produced by comparatively slight obstructions. It must be remembered, however, that these symptoms may be partly due to the accompanying urethritis or trigonitis. This author has found frequency of urination to be the symptom which most frequently induces the patient to seek medical advice, but Wynne states that in some cases the only symptoms noted by the patient are the small stream voided and the abnormal amount of time required to empty the bladder. Usually, however, there will be some degree of dysuria, and occasionally acute retention may first cause the patient to consult a physician.

Senile Stricture.—A form of stricture in the female, which was first described by Herman[18] and cited by Kelly and other recent writers, is observed in patients over fifty years old. There is a thickening and induration of the whole lining of the canal, which causes contraction of the lumen throughout its entire length. The contraction is sometimes so marked that it is impossible to pass a fine bougie. Herman found 6 case records in the literature, and made 3 reports of his own. He considered the condition analogous to senile hypertrophy of the prostate.

Diagnosis. It was Ely Van der Warker addressing the American Gynecological Society in 1904, who said: "I date our present knowledge of stricture in the male . . . to the invention and general use of exploratory bulbs and urethrometer. If we trust to the sound we simply learn that we have to deal with a narrowed passage, and we overlook obstructions of large caliber entirely; whereas, if we explore with the bulbs we learn not only all that the sound can reveal, but also the extent and number of the constricted points, their firmness and dilatability, and the differential diameter. I do not think my contention an unreasonable one when I state that the female urethra demands the same care and exactitude of exploration that we give to the male parts. . . . Women are so frequently the subject of bladder and urethral symptoms that the condition is nearly always explained otherwise. What in man would lead to a urethral exploration even on the part of a very ordinary surgeon, is overlooked in woman, except in cases of exceptional severity."

These words are just as true today, as when they were uttered more than twenty years ago. Olive-tipped or bulbous bougies should always be employed, even when it is possible to palpate the strictured area from the vagina, and no examination should be regarded as complete unless the urethroscope has been called into service.

Multiple strictures may be present, and if fistulæ have formed in the bladder or urethra, a stricture in the anterior urethra may remain undiscovered until the canal is invaded for the surgical correction of the coincident lesion. If a search is being made for gonorrheal stricture, the urethroscope will progress readily until it encounters the strictured area. As soon as resistance is encountered, removal of the obturator will enable the examiner to see the dull whitish scar tissue, and a careful inspection will show the constricted lumen which extends toward the posterior point of the urethra.

Treatment.—Though various forms of treatment have received endorsement from time to time even by competent gynecologists, accumulation of experience has demonstrated that there are but two general methods applicable to most of the cases seen in the ordinary run of practice. These are dilatation and operation.

Dilatation.—Rapid dilatation under gas anesthesia, passing Hegar's dilators until the canal is enlarged by 2 or 3 mm. is recommended by Kelly, but more recent work in our own clinic leads us to take a more conservative view. It is never wise to dilate more than six numbers at any one sitting, and it is far better to begin the dilatation with the largest sized sound or bougie that will pass, thereafter increasing no more than two numbers a week until an approximately normal caliber is attained, say something in the neighborhood of 26 French. After this a large dilator should be passed monthly for at least a year, and even after that occasional inspection and testing of the urethral lumen should not be entirely overlooked.[34]

Surgery is indicated when the stricture is evidently impassable, and also in some cases where it is possible to introduce a filiform bougie. Under these circumstances, internal urethrotomy is the procedure of choice. This is performed by Pugh as follows:

A filiform bougie is passed and a Rand knife with a fine blade threaded over this; thereafter an attempt is made to cut through the strictures. After the urethrotomy, sounds should be passed as recommended for the treatment of strictures of larger caliber.

Incision by a delicate knife is one method recommended by Kelly and Burnam, making multiple slight incisions and then gently passing the next size bougie. If there is much infiltration above the localized stricture area, making the restoration of the tissues a hopeless task, one may make an annular resection, cutting out the diseased part.

URETHRAL CALCULUS IN THE FEMALE.

As far back as the days of Celsus it was remarked that women suffered from stones in the urethra far less frequently than did men. The obvious reason for this is that the canal is so much shorter and more distensible as to offer little opportunity for the retention of calculi. Actually, the external meatus is about the only section which is capable of harboring a concretion. *Suburethral calculi* are occasionally found in sacculations adjoining the female urethra as has already been mentioned (page 339), these pockets usually have a communication with the urinary canal, and concretions so located are designated as diverticular or urethrocele calculi. They are not infrequently facetted, with a nice mutual adjustment by their flat surfaces while the entire conglomeration forms a well-defined ovoid body filling the sac.

The latest summary of literature we have found is not very recent, being that of Albertine and Reynard[1] who in 1910 collected 5 cases from the literature which had appeared since Quenu and Pasteau's[35] compilation of 13 cases, and added 1 of their own, making 19 in all. It is thus evident that urethral stone in the female is by no means frequently encountered. The case of Halban, published a quarter of a century ago, is still quoted, the most recent reference to it which we have found being contained in Branch's report concerning a young Chinese woman, which was published in 1924. This patient was aged twenty-one years and in the fourth month of gestation, although the stone, which is described as "about the size of an egg" must have seriously interfered with sexual intercourse; there is, of course, the possibility that it had rapidly increased in its dimensions after the onset of pregnancy. It had dilated the vesical sphincter and protruded into the vaginal orifice so that it was only with difficulty that the examiner could pass one finger beside it into the vagina. Dribbling of urine, owing to the dilatation of the sphincter, was, however, the only symptom of which complaint was made.

The patient reported by Halban[16] was an aged woman who had suf-

fered from prolapsus uteri for twenty-five years, and for some time back from periods of retention alternating with incontinence. Five stones, varying in size from that of a pea to that of a hazelnut, were found at operation, and after these had been removed, exploration of the bladder revealed a large number of vesical calculi, indicating a probable origin for those found in the urethra.

Pathogenesis.—It is probable however, that urethral stones may have more than one origin. In some cases the calculi may have first formed, and later their presence in the canal has led to sacculation, so that a pocket has been gradually shaped to receive them. A more common origin would be the supposition of the preëxistence of the sacculation in which decomposed urine, mucous concretions and possibly foreign bodies might lodge and become the basis for stone formation. On account of the anatomical structure of the female urinary outlet, calculi of the first class must of necessity be most unusual, but it is easy to see that, given the previous existence of a urethrocele, the formation of stone would be very likely to take place, should anything which could serve as a nucleus chance to lodge there.

Of Blackburn's[4] two patients, one had previously suffered from "bladder symptoms" and had finally passed the characteristic débris of a dermoid cyst *per urethram*, so that the nucleus was probably "some fragment of bone or a small portion of the granular material of the dermoid." The second patient, a negro girl, aged seventeen years, had inserted an octahedral glass pendant into the bladder, and when an attempt was made to examine this viscus because of symptoms induced by the presence of this foreign body, which in this patient suggested the possibility of venereal infection, the catheter came in contact with a hard substance which proved to be a calculus lodged in the urethra. This urethral stone was first removed, and later the encrusted glass pendant was discovered and extricated through a vesico-vaginal opening. Apparently some fragment from the bladder concretion had lodged in the urethra and served as a nucleus for the urethral calculus.

Symptoms.—Pain is by no means a constant symptom although it is very often present, but various difficulties with the urinary function are the most constant signs. Nocturnal frequency is almost invariably mentioned, and great urgency is a common complaint. Often dribbling, or complete incontinence will overtake the patient, and in most cases there will be an offensive puru-sanguinous discharge and blood and pus can be detected in the urine.

Diagnosis.—Diagnosis is not usually difficult. Often the stone will be visible at the meatus, as was mentioned in Branch's case. If not at once seen, it can usually be detected by vaginal palpation, which must, however, be carried out with extreme caution as the area where the stone is lodged will be highly sensitive. With the vaginal finger as a guide, it then becomes easy to locate the concretion in the urethra, using a metal or glass catheter or other suitable instrument. If the

stone lies in a deep sacculation it may be somewhat more difficult to determine its exact location, but the hard vaginal tumor is sufficiently characteristic to prevent mistakes.

Treatment.—In a number of the reported cases the stones have been spontaneously expelled, but this must be rated as a very rare occurrence. Rivet's[36] patient entered the hospital in the evening, the complaint being entered as incontinence of urine. When he visited her in the morning she informed him that during the night she had passed by the natural passages, a stone which she immediately displayed. It was indeed, a very good-sized calculus, still damp and covered with streaks of blood. The stone was so large that Rivet believed it to have passed through a vesico-vaginal fistula, but examination disclosed no such opening, while the meatus had become nothing more than an irregular gapping orifice, swollen and bloody, from which malodorous urine was escaping. The urethra when explored, proved to be hardly more than a jagged ring, within which several more calculi were lodged. The condition of the urethra was found to be due to the retention of a vesical sound, placed there after operation for prolapsus uteri, and left there for a long period, until it set up a virulent urethro-cystitis, which had received no proper treatment. The condition which he witnessed had, in Rivet's opinion, been brought on by the following sequence of events:

Cystitis; formation of secondary calculi; bladder becoming less and less "capax" under the influence of the effects of inflammation, and remaining constantly contracted upon its contents; one of these calculi, its pointed end being engaged in the urethral orifice, gradually dilates this opening, and being forced into the canal by the contractions of the bladder, works its way downward, increasing the caliber of the canal and decreasing its length, in much the same way that the progress of the fetal head dilates the genital canal. A much more likely outcome of a condition of such wide-spread inflammation would have been the formation of a fistula into the vagina.

The condition can only be corrected by the removal of the calculus by the most accessible way. In a few cases it has been possible to dilate the urethra sufficiently to permit the withdrawal of the stone by the natural route. More often, however, it has been found necessary to incise the vaginal wall, and if the infection is severe, to provide drainage for the urethral sacculation. Quenu and Pasteau treated one case by inserting a sound into the urethra, cutting down upon the imbedded calculus, shelling it out and then dissecting out the entire sac, thereafter closing the wound with two layers of sutures. This appears the most rational procedure, for the mere removal of the calculus cannot be relied upon for permanent relief of the condition nor the symptoms arising from it, inasmuch as, so long as the sac remains, the formation of more concretions is almost a foregone conclusion (see page 310, Diverticulum).

NEW-GROWTHS OF THE FEMALE URETHRA.

Caruncle. It was William Goodell, one of the most eminent of American gynecologists, who has left us this picture of urethral caruncle, as he presented it to his students at the University of Pennsylvania: "As I expose the meatus urinarius those of you on the lower benches can see, peeping out of it, a small crimson and wart-like body. It is called urethral caruncle, vascular tumor and vascular excrescence of the urethra. I hook up the base of the growth with a tenaculum, and by very gentle traction bring it wholly to view. It now looks like a small Antwerp raspberry and shows a broad base of attachment just within the lower verge of the meatus. Insignificant in size as this little growth is, it has embittered this woman's life for the past four years. Notice its vascularity; it bleeds on the slightest touch. Remark also, its extreme sensitiveness; although profoundly anesthetized, the woman winces and draws up her limbs. So exquisitely alert are the little nervelets distributed over its surface that were she not under the influence of ether, she would writhe under the brush of a feather. You must not infer that every case of caruncle presents symptoms as exacting as these. In the majority of cases there is no constitutional implication, and the woman complains merely of discomfort or of pain during the acts of micturition and of coition. But, on the other hand, worse cases will be met with—cases in which, by loss of rest, constant suffering and endless brooding, insanity has been induced. Some women have even been goaded by their anguish into committing suicide."[15]

Etiology. It has been claimed by Williamson and Atlee[50] that many of the so-called caruncles of the urethra, are nothing more than granulomata, that they are often of microbic origin and not infrequently that the causative organism is the gonococcus. The mucous membrane of the urethra by its cribriform arrangement offers an excellent nidus for the growth of such bacteria, and doubtless it is for this reason that these growths are so often found about the meatus.

Many pathologists, Virchow among them, considered caruncles to be innocent new-growths, but in the year 1894, Neuberger[28] studied specimens obtained from 12 different cases and found that in each instance the growth was a granuloma. This author's cases, however, were all drawn from a class of patients peculiarly subject to urethral inflammation, so his deductions cannot be unreservedly accepted. A few years after his work was carried out, Lange[25] made observations upon 1000 women, in 58 of whom caruncles were found; 39 of these were new-growths and 19 were granuloma. The observations of various authors lead one to realize that although the caruncle appears to be an insignificant and innocent formation, it still carries with it the potentiality of infinite injury and suffering, both physical and mental.

PLATE V

Caruncle of Female Urethra.

This vascular papillomatous mass was destroyed by one application of the high-frequency current. It was so equisitely tender that it was necessary to administer sacral anesthesia in order to accomplish its removal. There has been no recurrence in this case which was done three years ago.

Differential Diagnosis.—From his observations upon a large series of patients at the Mayo Clinic, Crenshaw[6] felt that but one conclusion could be drawn as to the etiology of urethral caruncles; namely, that they "seem to be secondary to a chronic irritation or ulceration of the urethral mucosa." Kelly describes a caruncle as a polypoid growth showing a framework of connective tissue, which is covered with squamous cell and transitional cell epithelium like that lining the lower urethra and its periphery. He emphasizes that at no point does it present the slightest resemblance to a malignant affection, neither should it be regarded as an inflammatory condition, as this differs from a new-growth in that the latter is distinctly and evidently a

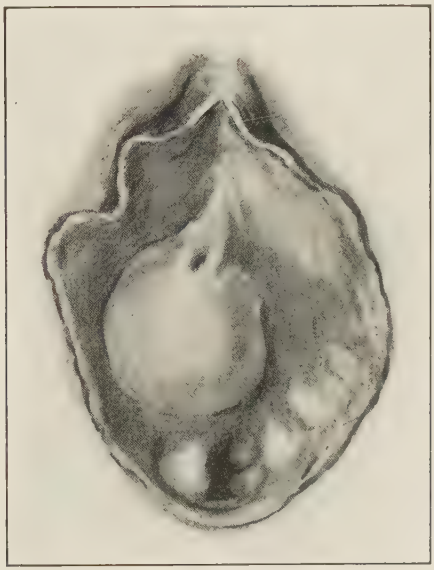

FIG. 108.—Benign fibrous tumor at the orifice of the female urethra. This tumor was excised under local anesthesia and did not return. The frequent and painful urination of which the patient complained, as well as the pain during coitus, were relieved.

localized tumor, springing from or grafted on to the tissues, and not simply a gross hypertrophy of the tissues themselves. Crenshaw states that some authors report a percentage of malignancy as high as 1 in 5 in the original caruncle, as well as many malignant recurrences. Williamson and Atlee mention that they have seen 2 cases of primary carcinoma of the urethra, in both of which a vascular caruncle had been previously removed.

Recurrence.—Recurrence, which is very frequent, is due either to the fact that the growth has not been completely removed, or is not a true recurrence but a prolapse of the urethral mucosa, caused by contraction of the scar-tissue left from the operative removal of the

original caruncle. The majority of so-called recurrences belong to the prolapse group; they involve a portion or all of the urethra, proportionate to the extent of the original scar. If this prolapsed mucosa is excised, the area of cicatrization is extended and the only result can be an increase in the prolapse.

Treatment.—*Operation* by the method employed at the Mayo Clinic, is said to prevent postoperative prolapse, and to be certain to avoid real recurrence: The patient is placed in the lithotomy position and after thorough cleansing with soap and water a swab of cotton on a toothpick, saturated in 10 per cent cocaine solution and lubricated with a soluble lubricant is inserted into the urethra and left for ten minutes. When the labia have been separated the caruncle will be found to consist either of a single tag on the posterior wall, or of posterior and lateral masses. Each tag is picked up with a small Graefe fixation forceps and clamped off in the long axis of the urethra with a special clamp which has a broad blade and a barrow crushing edge. The entire substance of the caruncle must be enclosed in the bite, without however, including any of the urethral submucosa. The caruncle is severed close to the upper surface of the clamp; the crushing of the pedicle effectually controls bleeding and aids in accurate removal of the growth. Nitrate of mercury solution applied with a wooden applicator, so as to thoroughly cauterize the cut surface, completes the maneuver, any tags which are present being removed and seared in the same manner. The advantages claimed for this procedure are that bleeding does not obscure the field, so that the operator may be sure that all the growth has been removed, and the small amount of scar tissue which later forms is in longitudinal lines and separated by islands of healthy mucosa so that a postoperative prolapse of the mucosa due to contraction of the scar does not occur. Another advantage is that the specimen can be saved intact for sectioning or any method of study.

Fulguration as variously recommended has undoubtedly proved efficient in some cases. The method employed by Ballenger and Elder[3] is as follows: The adjacent tissues are infiltrated with a 1 per cent solution of novocaine, and the d'Arsonval current applied until all the red appearance of the growth has been replaced by white. These authors found that less pain followed this procedure than had been caused by previous excision, and the destruction of the growth by various cauterizing agents, including the actual cautery. Moreover tumors which had persistently recurred despite all these measures permanently disappeared after fulguration, for although more than two years have elapsed there has been no sign of return.

Malignant Growths of the Female Urethra.—Both carcinoma and sarcoma are of very rare occurrence in the female urethra. When Percy,[31] in 1903, undertook to review the literature on that subject he was able to find but 15 reported cases to be added to his own. Three of these were sarcoma. Beckwith Whitehouse[49] increased this

list to 44 in a paper published in 1911, and some four years ago the number was augmented by Venot and Parcelier's[46] résumé of 87 cases, although they omitted to mention 10 of those on Whitehouse's list. In 1923, William Fletcher Shaw[39] added 3 more, which made exactly an even 100 cases reported up to the present.

Clinical Types.—Following the classification of Whitehouse, the malignant growths under discussion may be subdivided into the vulvo-urethral and the urethral growths. The first class may be again subdivided into three clinical types, which may be differentiated as: (1) An irregular dark papillomatous growth, bleeding readily on contact and resembling a simple polypus or caruncle. (2) An ulcer, due to breaking down of a nodule on the floor of the vestibule at the urethral orifice. The ulcer presents the ordinary malignant characteristics, having a hard irregular margin and a friable sloughing base. It rapidly involves the whole of the vestibule and spreads to the labia minora. (3) Induration around the urethral orifice, with depression, puckering and contraction of the opening, but no ulceration or proliferation. This variety is of slow growth.

Urethral Growths, which are much less common include the following: (1) An irregular elongated ulcer, involving the mucous membrane of the urethral canal, and usually situated in the distal segment, on the floor of the canal. It seldom involves the bladder, but tends to extend toward the urethral orifice, and has the usual malignant characteristics. (2) Periurethral induration with no ulceration until the later stages. The tumor tends to occlude the canal and involves the whole length of the urethra. It grows slowly and approximates to the scirrhous type. In the later stages there is ulceration of the vagina, urethra or vestibule.

Etiology.—It seems rather surprising that urethral malignancy should be so uncommon an occurrence, for it is generally accepted that the presence of continual irritation has much to do with the development of these growths, and, as Watson[48] has pointed out, it is an area exposed to a certain amount of irritation and injury; there is a junction of two epithelial covered surfaces, conditions which are supposed to favor the occurrence of malignant growths. We have already seen how urethral caruncle has seemed to be an etiological factor in not a few cases; stricture due to a preceding gonorrhea appears to supply a starting-point in some cases, and the lesions due to gonococcal infection do in all probability play a by no means insignificant part in the production of malignant neoplasms.

Diagnosis.—Most authors regard the diagnosis as easily made, only syphilis and benign neoplasm causing any confusion. Hirst,[21] however, considers that these similar conditions are very apt to cause the diagnostitian much trouble, and gives several cases illustrating how the symptoms were such as to lead even skilled practitioners astray. In one of these the final diagnosis of the pathologist was urethral inflammatory caruncle growing from an adenocarcinoma of the

urethra, which readily visualizes the difficulty experienced in making the clinical diagnosis.

Treatment.—The malignancy of all these urethral growths is very great, and comparatively few cures have been reported. Excision has proved fairly successful if undertaken early enough. In most instances, surrounding structures have been involved so that removal had to be very extensive, and incontinence and other miseries have made prompt death more of a boon than anything else.

Radium has been used successfully in both benign and malignant conditions of the female urethra. Pomeroy and Milward[32] treated true urethral caruncle with surface applications of radium element, and in their more recent cases have used a well screened tube which was inserted into the external meatus. Their procedure is as follows:

(1) Nitrous oxide anesthesia because of the exquisite tenderness locally, and because it permits of a thorough pelvic examination. (2) Excision of a small section of the growth for microscopic study. (3) Application of the cautery to the bleeding spot left by this excision. (4) Application of screened radium to the urethral canal, 50 mg. (silver, 0.5 mm., brass, 1 mm. and rubber 1 mm. serving as a screen), and the insertion of enough 5 mg. steel needles to occupy the growth and usually to surround the urethral canal. The radium is allowed to remain in position from three to six hours, a single treatment usually being sufficient.

Malignant growths should have much the same handling, but unless radium can be applied early, it can serve for little more than a palliative. However, even under these conditions its use is perfectly justified, as it lessens the pain, which toward the last is very severe, decreases the highly offensive discharge and makes the last days of both patient and family much more endurable. In our own experience, we have found the method of implanting "seeds" of radium emanation, in small amounts, not more than 0.5 millicurie, to be preferable to the use of needles. This causes less necrosis and consequent constitutional reaction, and distributes the action of the rays very evenly throughout the entire growth. The radium emanation is now being applied with gold or platinum screened tubes.

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CHAPTER XI.

THE PROSTATE.

EMBRYOLOGY OF THE PROSTATE.

Development of the prostate gland begins at the third month of intra-uterine life. If we examine the urethra of a fetus which has reached a vertex-breech length of 7.5 cm., two large solid evaginations will be seen to extend posteriorly from its floor. From these evaginations other larger ones will have developed, thus forming tubules, in some of which lumina will already be present. In others the lumen

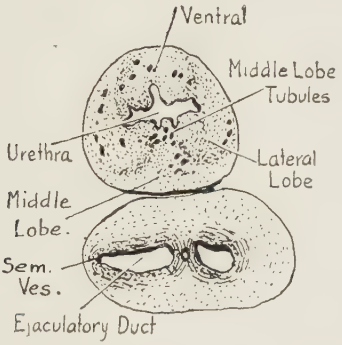


Fig. 109.—Cross-section through prostate, seminal vesicle, and ejaculatory duct of an embryo three and a half months old. This specimen shows solid epithelial outgrowths of the tubule groups forming the ventral, lateral and middle lobes. These later develop lumina. The posterior lobe tubules do not appear in this section. They are seen lower down or outerward. They communicate with the urethra below the entrance of the ejaculatory ducts. An evagination from the left ejaculatory duct shows the first beginning of the seminal vesicle.

will be but faintly suggested, while still others are entirely solid. These structures are undoubtedly developing prostatic tubules, separated by a considerable space from the main mass of prostatic tissue, and arising directly from the floor of the urethra in the position which anatomists have universally assigned to the middle lobe of the prostate, that is, between the bladder and the entrance to the ejaculatory ducts. From this point they extend posteriorly so as to occupy a position beneath the urethral floor and between the bladder and the ejaculatory ducts.

In a fetus 12.5 cm. long, aged about sixteen weeks, the tubules will be found to be divided into five distinct groups, the foci from which these groups take their origin being as follows: On the floor of the

urethra between the neck of the bladder and the openings of the ejaculatory ducts and of the utriculus prostaticus; one in each prostatic furrow and on the sides of the urethra; on the floor of the urethra below the openings of the ejaculatory ducts and the utricle; and on the ventral or anterior wall of the prostatic urethra. The tubules which originate from these five foci by their further growth and the development of stroma around them eventually become the middle, right and left lateral, posterior and anterior lobes of the fully matured prostate. Early in fetal life they are separated widely from one another, but in its later stages the separation between the middle and the two lateral lobes is not so great. Often in examining specimens of prostates

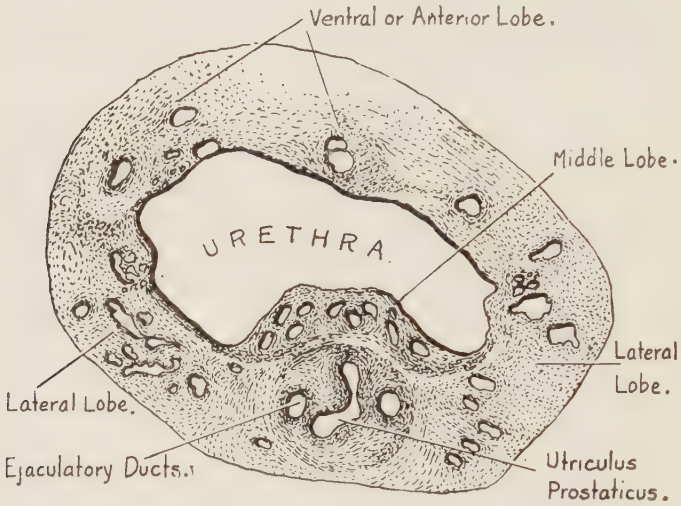


FIG. 110.—Cross-section through the prostate of an embryo aged five and a half months. The tubules have developed lumina and show branches. The ducts of the middle lobe tubules are grouped together in a separate envelope on the top of the verumontanum which is formed by the ingrowth of the ejaculatory ducts with the utriculus prostaticus.

removed from the new-born, the tubules of the middle lobe will be observed to lie side by side with those of the lateral lobes, with no definite capsule separating them. A rather dense layer of fibrous tissue always separates the posterior lobe from the lateral lobes, so that it is completely isolated, and the anterior lobe is set apart some distance from the two lateral lobes.

Musculature.—In examining a specimen sixteen weeks old, the development of muscular fibers around the prostatic tubules will be in evidence, and by the twenty-second week the muscular layers will be quite well developed, especially in those areas where the lateral lobe tubules extend away from the base of the prostate. The musculature thickens progressively, until at the close of the intra-uterine

period some of the tubules will be surrounded by very dense layers of muscular tissue.

Development of the Middle Lobe.—In practically all cases (in our investigations we have seen but one specimen which did not follow this rule) the middle lobe develops independently from tubules which originate from the floor of the urethra near the middle line, between the bladder and the entrance of the ejaculatory ducts. The tubules composing this lobe are separated from the lateral lobes by a considerable area of tissue which contains no glandular elements, and the younger the embryo, the greater will this separation be found to be. In the later stages of development, although the tubules and their branches maintain their characteristic position, there is apparently no definite formation of a fibrous capsule which would serve to separate the middle lobe from the lateral ones. Further development of the structures of the verumontanum serves to push up the largest of the middle lobe tubules, which lay originally near the middle line, so that they come to open rather high up upon the sides of the verumontanum, the middle line being occupied by the utriculus prostaticus and the ejaculatory ducts. If independent middle lobe tubules are entirely lacking, which was observed once in our investigations, branches from the lateral lobes will approach the middle line in the region which the middle lobe ordinarily occupies, and should this growth continue, this region will eventually contain a glandular commissure, such as Jores declares all middle lobes to be. In most cases the middle lobe is made up of some nine or ten large tubules.

The Lateral Lobes.—The lateral lobes are composed of tubules both larger and more numerous than those of any of the other lobes. They originate from the right and left prostatic furrows and the lower parts of the lateral walls, and extending backward and outward form the main part of the prostate's base. In early specimens these two lobes are widely separated from each other and from the other lobes of the prostate, but as development advances this separation lessens, so that the older the fetus studied, the less is the distance dividing the branches of the lateral and middle lobes, although in all specimens there is perceptible separation at the point where the ducts communicate with the urethra. In the region of the apex some of the lateral lobe tubules send branches forward, but at all other parts of the gland growth is backward toward the bladder.

In the prostate of the new-born near the apex, the lateral lobes have two extensively branching tubules which extend up into the anterior commissure and practically form a glandular commissure in this region. In most specimens a considerable area of stroma lies between the lateral lobes at their anterior aspect, and here are found the anterior lobe tubules. Mesially the ejaculatory ducts, urethra and middle lobe are interposed, a definite plane of connective tissue separating their posterior branches from the posterior lobe. The tubules forming the two lateral lobes vary in number from 27 to 46, the average being 37.

The Posterior Lobe.—The posterior lobe is made up of tubules which begin to develop with the other prostatic tubules at the third month. They are found on the floor of the urethra below the openings of the ejaculatory ducts, and their direction of growth is behind those structures back towards the bladder. In the 12.5 cm. length fetus, when development has been going on for about four months, the branches of these tubules are at no point in close touch with the lateral lobe tubules which come down to this point in the urethral wall; there also appears to be a definite layer of connective and muscular tissue taking form at this time around the different component parts of this lobe. The posterior lobe tubules compose the main mass of the apex of the gland, the posterior lobe being that section of the prostate which is palpable by way of the rectum. It is an independent structure, the tubules from which it develops being, as we have seen, separated from those which compose the other lobes, and divided from them by a definite capsule which is connected laterally with the capsule of the gland proper.

Importance of the Posterior Lobe.—For several reasons the posterior lobe is of considerable importance. Surgeons who undertake to do Young's perineal prostatectomy find it absolutely necessary to make their two parallel incisions deep enough to go completely through the connective tissue layer which separates this lobe from the two lateral ones. Should the incision extend only into the posterior lobe and fail to penetrate the lateral and middle lobes, which are the real offenders in prostatic hypertrophy, when enucleation is attempted the finger or instrument will go no further than the outer capsule of the gland, and enucleation will be impossible until the capsule which contains the lateral and middle lobes has been incised. From the studies of Geraghty and Boyd it is evident that hypertrophy rarely or never occurs in the posterior lobe, but primary carcinoma, on the other hand, is more likely to originate here than elsewhere in the gland. This knowledge, coupled with the embryological fact that the tubules which form it arise independently from a restricted area in the urethra and remain independent throughout, increasing enormously in size in the normal adult prostate, suggests the possibility that this lobe may have a different function from the other parts of the gland.

The Anterior or Ventral Lobe.—This lobe takes its origin from tubules which begin to develop at the same time as do those constituting the other lobes. In a four months' embryo these tubules may be seen extending along the ventral or anterior wall of the prostatic urethra, and though at first they are large and have numerous branches, by the time they have arrived at this stage of development they are relatively smaller than the tubules of the other lobes. By the twenty-second week they will have decreased still further in size and also in number and very few branches will be noted. After the sixteenth week the anterior lobe seems to shrink into insignificance, but its tubules persist until the end of the fetal period, for at birth two very

PLATE VI

This is a Sagittal View of a Wax Model of the Prostate of a New-born Baby Boy.

The prostatic tubules are represented with their branches grouped. U, Urethra, widening out above into the bladder; A.L., anterior lobe tubules which have shrunk to insignificance; U.P., utriculus prostaticus; A.G., subcervical group tubules; M.L., middle lobe tubules which occur between the urethra and E.J., ejaculatory duct; S.V., represents the seminal vesicle; Lat., lateral lobe tubules, some of which project forward into a position anterior to the urethra; P.L., posterior lobe tubules occurring behind the ejaculatory ducts. In the lower left-hand corner is a diagram representing the position of this prostate here represented as compared with the bladder. (*American Journal of Anatomy, 1912*)

small ones are found. There is evidence that occasionally the anterior lobe may persist into adult life, for among 93 specimens which we examined, 2 adult prostates were found with hypertrophied anterior lobes, and Kuznitzky found a persistent ventral lobe in 1 out of every 15 prostates.

Urethral Openings of Prostatic Tubules.—In most descriptions of the prostatic urethra it is stated that there are from twenty to thirty ducts opening upon its floor. A description of this section of the urethra has already been given (page 304). It has been the senior author's observation that the general average number of these duct openings is greater than has heretofore been supposed to be the case. In none of the specimens which he examined were there fewer than 53 prostatic duct openings into the urethra, and in 2 specimens there were as many as 74, the average for 6 specimens studied microscopically in series being 63, including 1 specimen in which the middle lobe was entirely lacking. The number of middle lobe tubules varies from 7 to 12, the average number lateral lobe tubules in 6 specimens being 37, while the posterior lobes show a variation of from 4 to 11, 8 being the average number in the 6 specimens recorded. The variations of the anterior lobe tubules have already been noted.

The Prostate in the New-born.—In Plate VI is shown a wax model of the prostate of a new-born infant. The sections from which this model was constructed were cut 30 μ in thickness. Every fifth section was magnified 20 times and drawn by means of a projection apparatus in use at the Anatomical Laboratory of the Johns Hopkins University. These drawings were traced upon wax plates 3 mm. in thickness, the tubules and their branches being first identified microscopically with great accuracy. The wax plates were then so cut that the bladder lumen and those of the prostatic tubules were left with bridges of wax between them to preserve the exact contour. The wax plates were then piled, using the axes of the bladder and urethral lumina, as well as those of the ejaculatory ducts, as points upon which to build. The prostatic tubules are represented with their branches grouped, it being evidently impossible to represent every branch of each tubule. The various parts of the model are held together by means of pins and copper wire, so that the exact position of the various structures represented is maintained. The separate parts of the model are painted with various colors of enamel, thus making clearer the difference between the component parts of the assembled model.

Summary.—The prostate begins to develop at the twelfth week of fetal life. It originates from five groups of tubules which begin as solid epithelial outgrowths, later developing lumina. These various groups arise from the floor of the urethra between the ejaculatory ducts and the bladder, from each prostatic furrow, from the floor of the urethra outward from the ejaculatory ducts, and from the ventral wall or roof of the urethra, and become the middle, right and left

lateral, posterior and anterior lobes respectively. The tubules grow, with few exceptions, back toward the bladder, and by the sixteenth week are surrounded by developing muscle fibers which in later stages become quite thickly disposed. In early stages the five lobes of the prostate are well separated from one another, but later development decreases the separation between the lateral and middle lobes, although in every specimen examined, save one in which the middle lobe was entirely lacking, the independence of these lobes is discernible. The lateral lobes make up the largest portion of the gland. The posterior lobe grows back behind the ejaculatory ducts, and becomes separated from these and from the middle and lateral lobes, by a plane of connective tissue. The tubules making up the anterior lobe are at first as large as other tubules and are quite numerous; but at the sixteenth week they are reduced in size comparatively speaking, and after this time appear to shrink into insignificance. All the tubules of the prostate seem to be firmly bound together within its capsule with the exception of those of the middle lobe, the upper ends of which seem in some specimens to extend beyond the capsule, lying freely between the vasa deferentia and the bladder.

ANATOMY OF THE PROSTATE.

We have seen that when fetal development is complete the prostate gland lies behind the second portion of the rectum at the neck of the bladder, which it surrounds posteriorly and laterally. It is encircled by a sheath called the prostatic fascia, the derivation of which is the recto-vesical fascia, and within this rather thin structure are found the vessels of the gland. It lies just outside the true prostatic capsule. The posterior surface of the prostate and seminal vesicles is covered by a glistening, rather light-colored fibrous plane of fascia sometimes so thick and firm as to be almost leathery in consistency. This fascia always extends to the apex of the gland, covering its entire posterior surface and extending laterally for a short distance beyond the surfaces of the prostate.

Denonvillier's Fascia.—Denonvillier's fascia, as this structure is called, varies greatly in the distribution of its upper border. The most commonly found arrangement is a semilunar outline, the lowest point of the concavity being just above the place where the vasa deferentia approach each other and become bound together in the same envelope. Laterally, the fascia projects into a horn-like process on each side, which covers the posterior surface of the seminal vesicles and is lost just above the upper end of each vesicle, where it gradually intermingles with the fatty and areolar tissues which accompany and surround the seminal vesicles and vasa deferentia. Nature has provided this firm barrier between the posterior surfaces of the prostate and seminal vesicles and the rectum, the importance of which will be appreciated when we come to consider the extension of malignancy from the geni-

talia to the rectum. Denonvillier's fascia adheres with moderate firmness to the posterior surfaces of the vesicles and vasa everywhere except at the upper border of the posterior lobe of the prostate, where it becomes very intimately attached, so much so that it can only be dissected free from it with the greatest difficulty. One leaflet extends between the prostate gland and the vesicles and is tightly joined to the prostatic capsule.

Except for the horn-like process of which mention has been made, the fascia is a very sharply-defined structure throughout. In specimens where the upper border is not of semilunar outline, it often extends further upward, even directly across from the upper end of one seminal vesicle to the other, so that the marginal outline is much less concave.

Blood Supply.—The blood supply is limited, practically all the small vessels which may be seen coursing through the tissue being confined to the upper layer, or that portion in contact with the vesicles and the gland.

Shape.—The prostate gland is often described as having the appearance of a horse-chestnut or English walnut, but neither of these comparisons seems to the authors to be sufficient. Its posterior surface is triangular and flattened, and there is usually a depression extending longitudinally in the mid-line, most prominent toward the base, and rarely if ever, existent at the anterior third. The upper borders bulge on either side, as do the lateral borders also, because these lateral lobes make up the main mass of the gland. The upper border receives the ejaculatory ducts after the junction of the vasa deferentia with the seminal vesicles in an elliptical funnel-shaped depression. The lateral borders are rounded, and between them and the gland's upper surface, lies an area defined with considerable sharpness. In young specimens obtained before puberty there is far less lateral bulging, but the general contour is about the same.

Size.—Careful measurements of 224 specimens obtained from routine autopsies have shown that in every instance the width of the prostate gland is greater and its thickness always less than the antero-posterior diameter. There is always greater prominence of the lateral than the middle portions of the base, so that in adult prostates the distance from the apex to the lateral prominences exceeds that from the apex to the middle of the base by 0.2 cm. to 0.5 cm.

Of specimens of the first decade of life most were obtained from subjects less than five years of age. As there is only a very gradual growth of the gland during these first five years, the prostate of a child at this age is surprisingly little larger than that of the new-born. The average length of the prostate during the first half of the first decade is 1.2 cm., the width 1.5 cm., and the length 0.9 cm.

As is to be expected, there is a great increase in the size of the prostate gland after the twelfth year. Indeed, the increase in this particular organ is proportionally greater than that observed in other organs of the body during the same period. The enlargement

apparently affects all the lobes to about the same degree and there is corresponding increase in the growth of the inter- and intralobular connective tissue. The muscular tissue surrounding the tubular elements becomes very markedly thickened; although in the mucosa there is no very marked change. The alveoli are lined by the usual simple columnar epithelial cells, their inner portions often showing acidophile granules, a pseudo-stratified epithelium with two rows of nuclei, as pointed out by Rudinger, being occasionally present. The basement membrane consists of delicate connective tissue threads, as mentioned by Walker. The ducts are supplied with a mucous membrane composed of simple columnar cells except at their orifices, where they are replaced by transitional epithelium similar to that of the posterior urethra. One specimen removed from the body of a boy, aged seventeen years, measured 2.28 cm. in length, 3.9 cm. in width, and 1.8 cm. in thickness, which is a nearly 100 per cent increase in the dimensions of the prostate during the period of puberty.

In general, during the second decade there is a very great increase in size. Ten specimens over fifteen years and under twenty years of age average 3 cm. in length, which is more than twice that of the average prostate during the first decade. The average width is 3.8 cm. and the thickness 2.1 cm. The prostate gland reaches adult size during the third decade, but few changes and these comparatively slight, occurring after that period. The average length is 3.3 cm., width 4.1 cm. and height 2.4 cm. Our conclusions regarding size will be seen to vary considerably from those of previous observers. Thus Wilson and McGrath[55] consider the average adult prostate to be 3.4 cm. in length, 4.4 cm. in width, and 1.5 cm. in thickness, with a weight of 16 or 17 grammes; Cuthbert Wallace[57] places its dimensions at 3 cm. for length, width, 3.6 cm.; thickness, 1.8 cm.; average weight, 20.5 grammes. Sir Henry Thompson writing in 1873, gave the average measurements of 50 normal adult prostates as follows: Length, 1.4 inches; width, 1.75 inches; thickness, 0.7 inch; weight, 4 drams and 38 grains. These figures correspond fairly well with those of Deschamps, Senn, Gross and Hodgson, but are somewhat smaller than those of Dupuytren.

During the fifth and sixth decades of life there seems to be a slight increase in all the dimensions of the prostate, but considering all specimens, this amounts to only a few millimeters. When old age is attained there is a noticeable decrease in size, so that specimens taken in the senile period resemble those of the third decade more than those of any other period of life. It is observable when examining specimens obtained during this period that they are either a little smaller and more atrophic in appearance than those of the age period preceding, or else are a little larger and display the characteristics of hypertrophy. It should be mentioned in this connection however, that prostate glands obtained from elderly and aged subjects show more abnormalities than those of other age periods; 56.1 per cent of our series showed some deviation from the normal, and in general one-

third of all specimens examined which were from subjects more than sixty years of age, showed more or less adenomatous hypertrophy.

Accessory Prostatic Glands.—In the region of the internal vesical sphincter lies a group of glands which seem to be of independent origin and to have no functional relation to the prostate. The most easily recognized of these are the glands of Albarran which lie beneath the neck of the bladder, and consist of thirty or more branched tubules, the ducts of which open proximal to the verumontanum in the middle of the urethral floor. Most of Albarran's glands lie in the mucous membrane inside the vesical sphincter, although a few may go down as far as the submucosa. The structure of these glands is not so complicated as those of the prostate proper, and they are without a definite muscular and connective tissue stroma. These glands are of great interest

FIG. 111.—Lateral and middle lobe hypertrophy of the prostate, with superimposed enlargement of the subcervical group.

and importance to the surgeon, for, on account of their anatomical location they are subject to many influences which tend to produce pathological conditions very frequently. A careful study of some 350 prostates collected from routine necropsies shows an enlargement of this group in about 25 per cent of the subjects who were over thirty years of age. In practically all cases of prostatic hypertrophy there is a considerable degree of accompanying enlargement in these accessory glands. This enlargement is apparently stimulated by the same factors which influence prostatic hypertrophy, and furthermore it appears that Albarran's glands respond to this stimulating influence even earlier than does the prostate proper.

The tubules of Albarran's group increase in number during the period of youth, occupying a position between the vesical orifice and the upper end of the verumontanum. In health their tubules are never sur-

rounded by the muscular or other differentiated tissue envelopes which characterize the structure of the true prostatic tubules. In some specimens the prevailing cell of the mucosa of the group is cuboidal.

FIG. 112.—Posterior view of the preceding specimen. The location of the vesical sphincter is clearly made out by the lateral striations on the posterior surface of the subcervical group enlargement.

FIG. 113.—Low power view of subcervical group enlargement. Occupying the major portion of the elevation are tubular structures lined with many layers of cuboidal cells which resemble embryonic prostatic tubules. Below these tubules are seen the circular fibres of the vesical sphincter.

These tubules begin to develop at the fourth intra-uterine month and increase slightly in size and number until birth. After puberty this increase is enormously accentuated.

Subtrigonal Tubules.—The subtrigonal tubules are another group found in the mucosa of the trigonum vesicæ, usually below the center, and occasionally as far anterior as the apex of the prostate, which reach or at times, penetrate the submucosa. The tubules are generally simple, those from younger specimens having no branches, although those of the middle age period will have one or two branches. Their histological structure is not distinctive, the lining being of transitional epithelium, similar to that of the bladder, the cells being much piled up, in some cases five or six deep. The lumina are usually quite small. The surgical importance of these tiny structures is two-fold: first because their position is such that any overgrowth or enlargement may impede evacuation of the bladder; and second, because enlargement of the group does actually occur often enough to merit the consideration of its possibility in diagnosis of any pathological conditions in this part of the genito-urinary tract. Young, Geraghty and others have observed cases where this group of tubules has become enlarged and a further growth caused them to become almost free in the vesical cavity, connected with their original site only by a small pedicle. When urination was attempted this globular mass fell into the orifice of the urethra, blocking it off more completely than would have been the case had an enormous adenomatous prostate been present.

Contiguous Structures.—It will be recalled that in the posterior portion of the urethra there is a longitudinal elevation some 3 mm. in height, the verumontanum. This tapers off gradually at both ends, and upon its anterior aspect is a fine slit, the opening of the utriculus masculinus, a longitudinal pyriform pouch which extends backward with the ejaculatory ducts. These structures have been described at length elsewhere (Chapter VIII, page 304). The orifices of the ejaculatory ducts lie on the right and left borders of the verumontanum, thus serving to make a division of the prostatic portion of the urethra into a proximal and a distal section. The orifices of the ducts of the lateral lobes of the prostate lie on either side of the verumontanum, while the ducts of the middle lobe open proximal to the verumontanum upon the posterior wall of the urethra. When ducts from the anterior lobe are present they will be found to open upon the anterior urethral wall.

Musculo-connective-tissue Portion.—This is composed of smooth muscle cells as well as elastic tissue fibers, and is the secretory portion of the prostate gland. Within is a dense fibro-muscular mass which surrounds the urethra and sends out muscle bands of transverse and longitudinal fibers which spread in all directions, following the connective tissue framework, and in some places looping about the glandular lobules, sometimes themselves constituting the interalveolar septa, no additional fibrous tissue being discernible.

Capsule.—The capsule of the prostate is so closely united with the fascia which surrounds it that it is very difficult to differentiate the two; indeed, it would be altogether impossible in most instances were it not for the fact that the fascia contains the venous plexus, and by

using this for a guide, the fascia can usually be separated from the capsule proper. When they have been dissected apart the capsule will emerge as a rough membrane covering the entire prostate, composed of involuntary muscle and fibrous tissue, and so firmly attached that any attempt to strip it off carries away part of the underlying glandular tissue.

Retrovesical Fascia.—The retrovesical fascia surrounds the prostate, being a structure springing from the linea alba, passing over the internal surface of the levator ani muscle and finally dividing into three layers. These layers are: An upper or anterior layer adherent to the prostate and the pubes, which passes over the gland's anterior surface and above its venous plexus; a median layer passing behind the posterior surface of the gland and under its lateral venous plexus; and finally a lower or posterior layer immediately adjacent to the anterior wall of the rectum. It is the two last-mentioned layers which constitute the aponeurosis of Denonvilliers. Wallace describes the fascia as connective tissue "simply playing the part of a packing," and thinks that giving definite names to its layers is likely to give rise to confusion and lead to erroneous ideas, since, although able to resist considerable pressure when this is applied at right angles to its surface, it is capable of being split into innumerable planes when the cleavage is performed parallel to its surface. It is usual to describe the fascia covering the levator ani as being reflected off this muscle and on to the prostate, to form the sheath of this organ. As a matter of fact, the levator ani muscles are in close apposition to the sides of the gland, and the interval between the two is filled with a many-planed areolar tissue in which are embedded some of the veins of the prostatic plexus. Between the triangular ligament on the one side, and the anterior surface of the prostate on the other, a similar arrangement is found, and in this fascia is embedded the anterior part of the prostatic plexus.

Veins.—The veins from within the glandular tissue and around the ducts emerge from the sides of the prostate, a portion of them passing into the capsular plexus and the remainder into the mucous membrane around the internal orifice and the verumontanum. The plexus pubicus impar lies on the anterior surface of the prostate beneath the edge of the symphysis pubis and behind the inferior pubic ligament. This plexus receives not only the blood from the prostate itself, but also that from the deep dorsal veins of the penis, as well as having communication with those of the seminal vesicles, rectum and vesical region, finally merging in the prostato-vesical plexus which forms a communication with the internal iliac veins.

Arteries.—The arteries enter the periphery of the gland in a number of different places, and by subdivision form a network of capillaries within the alveoli. The source of most of these vessels is the inferior vesical artery, but a few of them take their origin from the middle hemorrhoidal and internal pudic arteries.

Lymphatics.—The lymphatics lie upon the surface of the prostate as a fine network, but within, although found in considerable numbers at the base of the gland, there are but a few at its apex. Sappey describes the lymphatic plexuses at each side as forming two trunks, one superior and the other lateral, the first passing to the obturator lymph glands of the pelvis, and the other to the internal iliac lymph glands. A finely granular protoplasm composes the endothelial cells of these lymphatics.

Nerves. -The prostatic nerves take their origin in the pelvic and hypogastric plexuses, so that they are in connection with the second, third and fourth spinal nerves of the sacrum. In their branches will be observed both medullated and non-medullated fibers, and ganglion cells of relatively large size. The course of the nerves is along the bloodvessels from the surface of the levator ani muscle to the posterior and lateral border of the gland, whence the prostate and the seminal vesicles are innervated, and the plexus is eventually distributed to the erectile tissue of the penis.

Clinically, it has long been recognized that pathological conditions of the prostate are accompanied by numerous severe nervous disturbances. The most common of these are the referred pains which occur in the small of the back, in or about the rectum, and down the legs. Timofeew,[49] in his very complete study, has described a complicated system of nerve fibers and endings which assists greatly in understanding this feature of the anatomy of the prostate. Von Planer gave an account of numerous nerve endings situated in the superficial layer of the mucous membrane of the prostatic urethra, and Timofeew tells of a wide-mouthed plexus of medullated fibers within the deeper layers of the capsule. Fine non-medullated fibers pass through the prostate from the plexus and, branching freely, end between the epithelial cells. Other branches form tuft-like end-bodies, and still others encapsulated end-organs. Some of these resemble Pacinian corpuscles with two fibers each, one of which is thick and enters as a naked axis cylinder, ending in the opposite pole as a pointed or knob-like structure; the other is thin, loses its medullary sheath, forms a finely divided fibrillary web and surrounds the axis cylinder of the first fiber as a loose tunic, although it does not come in contact with it. This investigator describes another nerve ending as a single fiber more or less branching in all stages of transition from the simplest cylindrical form up to the multiple branching forms, in addition to the usual Pacinian corpuscles. Besides the sensory fibers, he mentions the existence of many others which are apparently secretory, as they resemble similar fibers in other glandular structures. He also describes both motor and sensory end structures on the striated fibers of Henle's muscle. They are at first medullated, but terminate as non-medullated fibers. The nerves of the smooth muscle-fibers are non-medullated, forming between the muscular layer thick plexuses of varicose fibrillæ which send out numerous branches.

PHYSIOLOGY OF THE PROSTATE.

The earlier conception of the function of the prostate was that it was an essential part of the urinary apparatus, and was only secondarily concerned in the genital function. At present, however, it is recognized as a part of the genital tract which has no part in the function of urination. The evidence classing it as a sexual instead of a urinary organ, has been thus summed up by Wallace: (1) It is confined to the male sex; (2) it enlarges rapidly at puberty along with the other sexual organs; (3) it exhibits seasonal activity in animals—such as the mole and the hedgehog—which mate only at certain seasons of the year; (4) it fails to grow in individuals castrated in youth; (5) it atrophies in individuals castrated in adult life. As removal of the prostate does not necessarily render an individual incapable of reproduction, it is apparent that it is only of secondary importance. According to Wilson and McGrath, in order to correctly appreciate the physiology of the prostate three points must be considered: (1) Its function as a secreting gland; (2) its muscular apparatus, especially its sphincter formation; (3) its extraordinary wealth in nerve fibers, ganglion-cells and nerve end-organs.

Muscular Apparatus of the Prostate.—Beginning by taking up their second point: The muscles which surround the ducts of the prostatic tubules are intimately connected with the circular muscle coat of the urethra, and the extrinsic muscles of the urethra play an important role in the process of urination and ejaculation. The compressor urethræ muscle, which lies within the deep perineal interspaces between the layers of the triangular ligament, passes from one side to the other and encircles the membranous portion of the urethra. It is a voluntary muscle, which maintains itself in a state of tonic contraction. The external vesical sphincter is continuous with this muscle above, surrounding the urethra at the apex of the prostate, and intimately associated, not only with the sheath and the musculature stroma of the gland, but also with the pelvic fascia, which at this point stretches between the pelvic rami to form the deep layer of the triangular ligament.[19] Deaver says that incontinence of urine following prostatectomy usually means injury to both sphincters. Normally the internal sphincter muscle is held in a state of tonic contraction under the control of the hypogastric nerves, and urination can only be accomplished when the inhibitory influence of the spinal center which maintains this tone, is removed, permitting the muscle to relax. The prostate gland is entirely passive during the act of urination which is a function of the neuro-muscular system of the bladder and the urethra. The investigations of Wilson and McGrath, however, led them to conclude that the musculature of the prostate expresses the prostatic secretion into the urethra and that the sphincter internus and the sphincter externus are essential parts of that gland and concerned in bladder closure, the internal sphincter by its constant tonus, and

the external sphincter when, in the case of a distended bladder, the so-called "bladder-neck" is formed. They regard as experimentally demonstrated the ability of the voluntary perineal muscles to act in an accessory manner in producing bladder closure and urinary discharge, so that the pars prostatica urethræ must be considered an important factor in the production of the sensation of urinary pressure often felt when the bladder is empty and diseases of the prostate are present.

Function of the Prostate Gland.—The function of the prostate gland is now accepted to be chiefly secretory, that is, it furnishes a liquid medium chemically and physiologically suitable to the needs of the spermatozoa in their passage from the genital glands. But the fact that many observers have been able to effect impregnation with spermatic fluid aspirated directly from the testicles seems to indicate that the admixture of prostatic secretion is not vitally necessary to the life or activity of the spermatozoa.

Prostatic Secretion.—Prostatic secretion is a thin, somewhat opalescent fluid, possessed of a slightly acid or neutral reaction, and giving off a characteristic aromatic odor. The "milky" appearance of the fluid is due to the presence of large, colorless, moderately refractive, round granules, and there are also to be found stratified amyloid bodies, leukocytes, round and columnar epithelial cells, as well as lecithin and albumin. Launois long ago noted[23] that the prostate does not become an active gland of secretion until puberty is attained, this activity being coincident with the formation of spermatozoa in the testicles. The prostate's sexual activity continues to increase until after the twenty-fifth year, but when the thirtieth year has been attained this power seems to remain stationary and shortly thereafter begins to decline. After the fortieth year the fibro-muscular stratum becomes relatively thicker, which may be regarded as the first harbinger of senility.

ANOMALIES OF THE PROSTATE.

An attempt to review the literature on anomalies of the prostate will quickly convince the investigator that the usual text-book statement that they are rare, is indeed well founded. Among the references in the Surgeon-General's Library catalogue which fill more than forty double-columned pages of very fine print, comprising many thousands of items, there are exactly *two* which refer to prostatic anomalies, and these are in obscure foreign journals to which we were unable to gain access. In literature which has appeared since this catalogue was issued, there are a few mentions of abnormalities which have been observed in the gland, but they are not of great importance. It is altogether likely that such anatomical irregularities occur much oftener than we are thus led to suppose, and are frequently overlooked, either because they appear in conjunction with extensive malformations in

other genital organs which are of so much greater importance as to completely overshadow them, or because they are of such a nature as to cause no interference with normal function anywhere in the urogenital tract, so that attention is never directed toward the prostate. Young has remarked that the close association both embryologically and physiologically, of the testicle with the prostate, and the dependence of the latter upon the former for its proper functioning and development, makes the prostate peculiarly susceptible to abnormalities of the testicle. The large proportion of the abnormalities of the prostate as a whole are associated with the condition of cryptorchidism. Here arrested development and bilateral atrophy of both lobes exist in varying degrees. In Launois's study, mention is made of several patients who presented monorchidism, in whom it was observed that the prostate was undeveloped on the side where the testicle was missing, as was also the seminal vesicle of that side; the opposite organs were normal.

Absence of the Prostate.—Complete absence of the prostate has been rather recently reported by Dowd,[13] and in an extensive study of endocrine deficiency in conjunction with retarded and imperfect genital development, Lisser[24] cites 13 cases where no prostate whatever could be palpated. Dowd's patient was married but childless, and it was in the course of an examination to discover if possible the cause of his sterility that the absence of the prostate was noted, for there had been nothing other than the sterility which gave evidence of abnormality of any part of the genitalia. Lisser's patients all presented evidence of abnormality other than that of the prostate, several of them being mentally deficient as well.

INJURIES TO THE PROSTATE.

External Injury.—The prostate is not often subjected to accidents, so if it suffers trauma it is likely to be in the course of surgical operations, or some manipulation or instrumentation. Situated as it is, contusions or lacerations, such as befall the urethra below or the bladder above as the result of falls or blows, seldom occur, for the pubic and ischial rami and ischial tuberosities afford it excellent protection. If some violent force falls upon the buttocks these bony ramparts will in practically all cases serve to protect the prostate from injury. Although accidents frequently bring violent force to bear upon the perineum, the distance to which the prostate is removed is still considerable, and moreover the tissues of the region about the anus and the ischio-rectal fossa are so elastic that they constitute a sort of cushion of muscular and cellular structures which takes the full force of the violence. Lydston[26] states that instances are on record where the membranous urethra has been torn completely across and yet the prostate has escaped injury, although the rent was directly at its apex. If a crushing injury is severe enough to involve a struc-

ture so deeply situated as the prostate it is practically certain to prove fatal, although exceptionally the gland may be pierced by a fractured pelvic bone when the surrounding tissues are not greatly damaged.

Occasionally, punctured or incised or lacerated wounds may be inflicted on the prostate, as when an individual falls astride of some pointed object which pierces the perineum and thus reaches the prostate. This has happened when the fall was from a considerable height upon a picket fence. Very rarely glass, or something similar has been introduced into the rectum and piercing the rectal wall has penetrated as far as the prostate. Wounds caused by fire-arms are still more infrequent. Ricord has cited one case in which a musket-ball penetrated the false pelvis, passed downward through the iliac fossa, entered the true pelvis and penetrated the prostate. It was detected by digital examination of the rectum and extracted by perineal section.

Internal Injuries.—Careless or unwise instrumentation is a very frequent cause of prostatic injury. If the instruments used are small and especially if they are sharply pointed, even a normal prostate may suffer, as the urethra makes a sharpe curve in the region of the triangular ligament, and a catheter may be impeded in the bulb, when the external or bladder sphincter is spasmodically closed, so that instead of traversing the route intended the instrument may pierce the urethral wall, pass through the tissues outside the urethra and penetrate one of the lobes of the prostate. It is by no means uncommon to see a false passage passing through the prostate which has its commencement in the prostatic urethra, or somewhere in the urethral wall anterior to the apex of the gland. The cause of these false passages is usually enlargement of one or more of the lobes or a urethral stricture, which render the shape of the urinary passages so irregular and abnormal as to make the proper passage of a catheter or other instrument practically impossible. Elsewhere we have discussed the various problems offered by catheterization, and the possibility of prostatic injury only emphasizes the great need of care and the utmost gentleness in every maneuver of this kind.

Trauma Due to Operation.—In practically all perineal procedures the integrity of the prostate is more or less hazarded. In the old-fashioned perineal lithotomy it stood no chance of escaping unscathed, and except in the simple median operation, it is very likely to be more or less injured. As has already been noted, the removal of calculi is prone to cause considerable damage to the prostatic tissue, and the wounds may easily extend beyond that area until they involve structures outside the fascial envelope of the gland, such as the cellular tissue of the pelvis or peritoneum.

Before prostatic surgery had reached its present standard the occurrence of any such wound was a dangerous matter, for they were peculiarly liable to sepsis, the facilities for proper drainage were very poor indeed, and severe and even fatal hemorrhage might easily become a

complication. Improved technic and anatomical and pathological knowledge have served to lessen, and in many cases completely obviate these dangers, but it is well to bear in mind the possibility of injury and never to relax the utmost precaution to prevent its occurrence.

Hemorrhage is especially to be guarded against. In considering the question of hemorrhage from operative or accidental wounds of the prostate, it is well to remember that the region of this gland is very vascular, and rather difficult of access for the application of methods of hemostasis. Retention of urine from congestive or inflammatory occlusion of the urethra, or complete or partial obliteration as a result of the traumatism, is likely to be an important consideration in prostatic injuries. Pyogenic infection and abscess, possibly followed by urinary fistula, and septic cellulitis are serious results that are likely to occur in extensive injuries, especially when drainage is imperfect. The septic cellulitis may be limited to the ano-perineal region and ischio-rectal fossa, or may extend over a large area of the subcutaneous and internuscular planes of cellular tissue. If the wound extends beyond the bounds of the prostate, septic pelvic cellulitis or general peritonitis may develop, these being intrinsically fatal. The conditions which prostatic injuries may induce and the dangers to which the victim of them is subjected will be noticed to be in general, the same as those which characterize trauma to the bladder or any part of the urethra.

DISEASES OF THE PROSTATE GLAND.

Inflammation of the Prostate Gland. Acute Prostatitis. The most frequent cause of prostatitis is gonococcal infection. Practically always some involvement of the prostate will follow every case of posterior urethritis. Careful observations by several writers on bacteriological subjects who have made studies upon urethritis, show that besides the gonococcus, the *Staphylococcus albus*, the *Streptococcus pyogenes*, the colon bacillus and a slender organism which has not yet been identified, may be present, mixed infections being far from uncommon. Albarran and Cottel reported to the International Congress of Medicine held at Paris in 1900 that in 3 cases of prostatic abscess they had identified the colon bacillus, the streptococcus, staphylococcus and gonococcus. Cohn reported in 1898 that he had found the *Staphylococcus albus* 11 times, the colon bacillus once, a diplococcus twice, and an unidentified bacillus once. The prostate is undoubtedly one portal of entry for septicemia, and when the gonococcus is the offending organism, it is practically always the original focus.

Types.—There are three types of acute prostatitis generally recognized, the most common being acute catarrhal inflammation, which is always present in acute posterior urethritis, and is usually caused by direct migration of the gonococcus into the tubules. The contiguous

organs, including the utriculus prostaticus, the ejaculatory ducts and the seminal vesicles, may be affected at the same time.

Following the first type, the second or follicular prostatitis, develops. This condition is characterized by the formation of small abscesses, or dilatation of the prostatic tubules with pus, which is not evacuated because of some obstruction in the ducts, due perhaps to temporary edema or other causes.

Tertiary or parenchymatous prostatitis develops from an intensification of the secondary stage, the small collections of pus becoming larger, and a greater extent of the stroma surrounding them becoming involved. Finally the entire gland increases in size, being hot, tender and tense, and is even likely to disintegrate so that it clinically forms a large prostatic abscess.

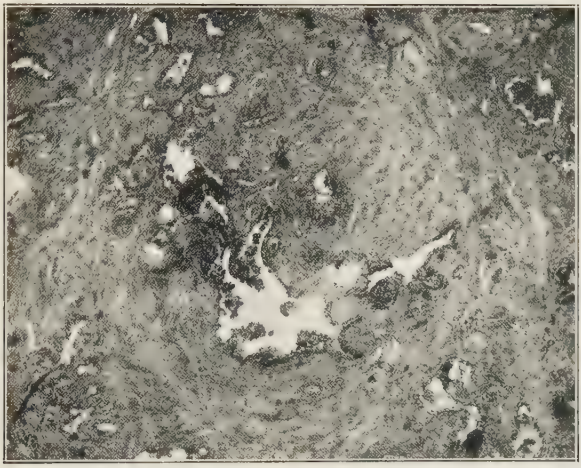


FIG. 114.—Photomicrograph showing a small abscess of the prostate consisting of a central necrotic area surrounded by a connective-tissue wall. Outside of this are seen some prostatic tubules filled with exudate.

Chronic Prostatitis.—There is a wide difference of opinion as to the frequency of the occurrence of chronic prostatic inflammation. As early as 1815 Lagneau called attention to the fact that chronic prostatitis frequently complicated gonorrhea. The first accurate description of the pathology of chronic prostatitis was given by Verdier in 1838. Montagnon, Eroud, Pezzoli, Casper and Wallach found chronic prostatitis as a sequel to gonorrheal urethritis in from 70 to 94 per cent of their cases. Hogge and Frank state that every case of posterior urethritis is complicated by prostatitis, but Guyon and Fürbringer on the contrary, regard prostatitis as a rare condition. In our series of 350 postmortem studies, a large number of the specimens examined showed evidence of inflammation of the prostate gland.

Etiology.—Chronic prostatitis was found by Young, Geraghty and Stevens[59] to have followed gonorrheal urethritis in 73.2 per cent of their cases; masturbation in 7.5 per cent; prolonged sexual excitement without coitus in 4 cases and withdrawal in 0.8 per cent; instrumentation in 0.6 per cent; traumatism in 0.8 per cent; infectious disease (influenza) in 0.3 per cent, and no etiological factor discoverable in 14.8 per cent. Bierhoff[5] found that 57 of his 62 cases of chronic prostatitis were due to the gonococcus, and that the remainder were the result of a mixed infection. On the other hand more careful

FIG. 115.—Distorted prostatic urethra. The tip of the verumontanum is seen at the top of the picture. Below this stretches the lower portion of the verumontanum which is elevated above the floor of the urethra. The prostatic duct orifices seen are badly diseased, being held open by the inflammatory tissue surrounding them. On the left side the openings communicating with two abscesses are noted.

studies by Porosz[36] and Cohn[8] led them to believe that the gonococcus is not so frequently the etiological factor in chronic prostatitis. Wassidlo, Schromm, Jadassohn, Ruggles and Goldberg believe that a mixed infection is the usual finding. It is our own observation that after every case of posterior urethritis the prostate is more or less involved, this involvement being manifested by the persistence of comma-shaped casts of the prostatic duct orifices in the urine; nodulation and induration of the prostate gland itself, and the appearance of more than the usual quantity of pus cells in the prostatic fluid.

Only immediately after the inflammation has subsided is the gonococcus to be found.

Examination of Prostatic Fluid.—In treating a case of chronic prostatitis frequent examinations of the fluid expressed by massage of the gland should be made with the microscope, as the conditions present in the gland can be ascertained in this way much better than by palpation. Notthafft[34] quite properly states that changes in the secretion are much more frequent than changes in the prostate evidenced by palpation, and he also points out that pus in some instances does not make its appearance until after the prostate has been massaged from two to five times. We have observed that after massage has been carried out for a long period, the induration may entirely disappear, but the prostatic fluid, will remain loaded with pus. After persisting for some time this condition may suddenly alter, the pus disappear from the fluid and rapid cure take place. The fluid should be stained at least once, to ascertain the presence or absence of bacteria. We regard the prostate as a frequent focus of infection, and second only to infected tonsils as a cause of arthritis; it may also be responsible for endocarditis and neuritis.

Symptoms.—The signs and symptoms of chronic prostatitis are varied; to the familiar pains in the back and "morning drop" may be added almost any degree of sexual disturbance, always accompanied by neurasthenia. The pain which is usually located in the small of the back, may be described simply as a "heaviness" in the rectum. This type usually gives a history of the passage of prostatic fluid on defecation. The pain may be referred down the back or the inner sides of the legs, or into the groins; not infrequently prostatic pain may simulate that produced by renal calculus.

Frequent and painful urination is a common complaint, and mention is frequently made of hesitancy and precipitancy. Examination of the urine practically always shows shreds, usually the comma-shaped casts of the prostatic duct orifices. Rectal palpation reveals a hard and nodulated prostate, and usually adhesions may be felt extending from the lateral border of the gland to the seminal vesicles and adjacent pelvic tissues. Such a prostate is ordinarily enlarged and at times there will be boggy spots between the areas of induration. No case of prostatitis should be considered properly examined unless cystoscopy has been carried out, but it is often wise to delay this procedure until the most acute and distressing symptoms have been allayed by treatment.

Tuberculosis of the Prostate.—Tuberculosis of the prostate is undoubtedly a pathological entity very infrequently encountered. Walker[50] who went over the available literature very carefully about a dozen years ago, made the following summary of instances of secondary involvement: "Simmonds reports 35 cases of genito-urinary tuberculosis in which the prostate was involved 26 times. Oppenheim in 27 cases found 18 with prostatic tuberculosis; Collinet, in 70

cases found it 44 times. Krzywicki, in 15 cases of genito-urinary tuberculosis found 14 involvements of the gland. Hallé and Motz in 72 cases of genital tuberculosis, found 59 showing lesions of the prostate. Saxtorph, in 10,016 autopsies at Copenhagen, finds records of 547 cases of tuberculosis of the genito-urinary tract. In this number, isolated tuberculosis of the prostate was found 9 times." Walker reviews a large number of supposedly primary instances of tuberculosis of the prostate, but rejects most of them because there were no cystoscopic examinations excluding vesical tuberculosis, and also because the authors assumed that the focus most advanced in appearance must of necessity be the oldest, which is not always the case. He admits, however, that primary tuberculosis of the prostate does occur, mentioning the finding of Crandon, who observed at autopsy a tuberculous mass in the prostate with no other tuberculosis in the body, which Walker regards as an undoubted instance of a primary and isolated tuberculosis of the gland. Secondary involvement of the prostate in a tubercular process can well be relatively common, the gland standing as it does a meeting-point between the kidney above and the epididymis below, so that it is subjected to infections from both the genital and the urinary systems.

More recently reports of carefully verified primary tuberculosis of the prostate have been published by Koll[21] and Barney[2] as well as a complete autopsy record by Scott[38] which is of especial interest because of the advanced age of the patient, and the difficulties in diagnosis which were encountered. Koll has very pertinently remarked that the scarcity of such cases in the literature does not represent a true percentage of the primary invasion of the gland by the tubercle bacillus, but a deplorable failure on the part of the surgeons to have careful histological examinations made of their specimens. It is probable that the possibility of tubercular invasion of the prostate is very seldom considered in subjects who are beyond the age which we usually associate with liability to uro-genital tuberculosis, and are passing through the age period when hypertrophy is very common and malignancy an ever present possibility. Benign prostatic hypertrophy was present in 2 of the cases just mentioned, and Scott remarks that the differential diagnosis between early carcinoma and old fibrous tuberculous nodules of the prostate in men of the cancer age is especially difficult, in fact so difficult, that the presence of the latter condition is often first realized when the pathologist renders his report. Therefore, in cases that present the slightest findings which are not in keeping with those of definite carcinoma of the prostate, a careful restudy should be made with the idea of ruling out, if possible, a tuberculous condition.

In general, however, tuberculosis of the prostate is a disease of the young adult, and will be observed in the third and fourth decades of life. Its origin is probably hematogenous in most cases, although it not infrequently accompanies a tuberculosis of the epididymis

and seminal vesicles. Under these circumstances the lesion may be largely confined to that side of the prostate where the seminal vesiculitis is located, and this would suggest that the infection may also be conveyed by the lymphatics. The lymphatics of the lungs, alimentary tract, tonsils and glands of the neck have all been suspected at various times. The lungs should always be most carefully scrutinized in all cases where a tubercular infection is apparently confined to the uro-genital tract.

In the authors' series of tabulated cases, numbering more than 500, about 10 cases of prostatic tuberculosis have been observed. Examination reveals a nodular, elastic gland, usually affected on but one side, but differing from a carcinomatous infection in that it lacks the board-like consistency always associated with the presence of malignancy in the prostate. Apparently the tubercle bacilli are at first deposited in the walls of the small capillaries, other tubercles developing from these original foci which extend in the usual manner, the bacilli ordinarily being observed at the borders of the tubercles.

Syphilis of the Prostate.—All authors agree that the prostate is singularly free from infection by the *Spirochæta pallida*. We have personally never encountered a case of prostatic syphilis. Just why the prostate, which seems peculiarly liable to harbor practically every other infection, should be immune to such a ubiquitous disease, is a question not without interest. The literature upon the subject was gone over by Thompson[48] about five years ago, who found but 24 recorded cases of prostatic lues, 12 of which he considered doubtful. Since then McDonagh[30] and Starry[42] have made communications concerning syphilis of the prostate, but it still remains one of the most infrequent infections of this gland.

Pathology.—We have but one pathological description of a syphilitic prostate, that given by Warthin[52] in the report of a postmortem examination upon the body of a young man with early tertiary syphilis clinically latent. Diffuse plasma-cell infiltrations occurred throughout the stroma of the organ, and not around the gland spaces as in chronic gonorrhea. The infiltrations were perivascular, interstitial, and not periglandular or subepithelial. Fibroblastic and angioblastic proliferations were prominent and numerous giant cells occurred in the larger infiltrations, giving them the character of miliary gummata without caseation. Groups of spirochetes were found in these. This case was the first one of a series of 37 where evidences of luetic infection were observable, in which a syphilitic lesion of the prostate was found.

In all the recorded cases of prostatic syphilis, enlargement of the gland was the chief feature of the gross pathology, and in some of the reports the palpation of nodules is mentioned.

Symptoms.—Pain in the perineum, sometimes independent of urination but in most cases aggravated by this act, is the manifestation most commonly mentioned. A few patients have shown a slight dis-

charge, and in most, prostatic massage produced an exudate more or less characteristic. Hematuria and pain on defecation or coitus, are also mentioned as occasional accompaniments of this condition. The urine is usually cloudy and on microscopic examination will show pus and epithelial cells, together with some blood corpuscles. However, as Thompson says, "there is nothing pathognomonic either in the symptomatology or the findings by rectal examination, so the diagnosis must rest on other evidence."

TUMORS OF THE PROSTATE.

Non-malignant Hypertrophy.—As Keyes has pointed out, prostatism may be either sclerotic or adenomatous in type. Much has been written upon this subject, and the theory was advanced by Simpson[40] that the condition is caused by the growth of multiple adenomas; that these changes are most marked at the oldest part of the new-growth, and therefore correspond to such growth centers as have been demonstrated. He reviewed the literature very thoroughly, and found many authoritative statements which substantiated his view. Beginning with Albarran, the majority of French investigators—Motz and Perearnau, Marion, Marquis and Chevassu—hold that prostatic enlargement is due to true tumor formation, their only difference of opinion being in regard to whether they take their origin from peri-urethral accessory glands, or whether they may spring from any part of the prostate gland itself. But the conception that prostatic hypertrophy is the result of long-standing inflammation, more particularly involving the urethral portion of the gland is still supported by pathologists of such eminence as Adami, as well as many others.

The thorough and minute study of the entire subject of prostatic hypertrophy which was issued by Tandler and Zuckerkandl in 1912[46] has remained an unrivaled contribution to our understanding of this exceedingly complex subject. Being unusually fortunate in the matter of available pathological material, they were able to make observations both upon postmortem subjects and operated patients, dissections of 42 cases being used as a basis for their report. According to their observations, hypertrophy of the entire gland never takes place; they contend that the process always begins in the middle lobe, which in its enlargement encroaches upon and compresses all the other portions of the organ. Our personal studies have shown that the portion of the gland which enlarges most frequently is really a contiguous structure, the subcervical group of tubules. Simmonds' conception[39] is that the prostate, in contradistinction to the submucous glands, undergoes presenile changes similar in character to those observed in other organs as age advances; atrophy of the prostate takes place, the submucous glands being the structures which actually undergo hypertrophy. It has been the authors' observation that the subcervical tubules are enlarged in more than 23 per cent of males over thirty years of

age, and that this may occur without any enlargement of the prostate whatever. And when the prostate itself is enlarged the subcervical group will also show some hypertrophy.

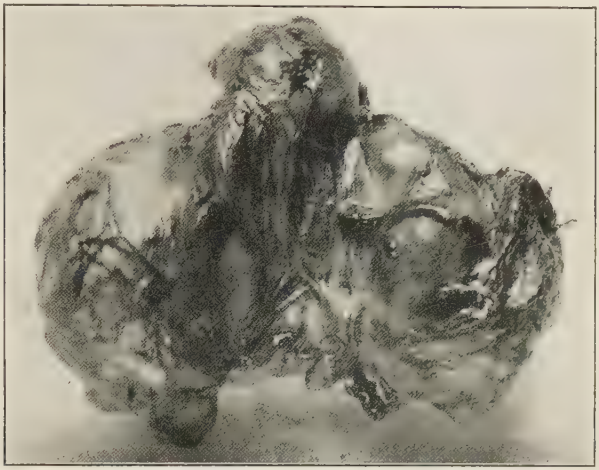


FIG. 116.—Enlargement of the lateral and middle lobes, accompanied by an enlargement of the subcervical group. On account of the strategic position occupied by the latter (inside the sphincter on the floor of the vesical orifice) it may often be the chief cause of obstruction.

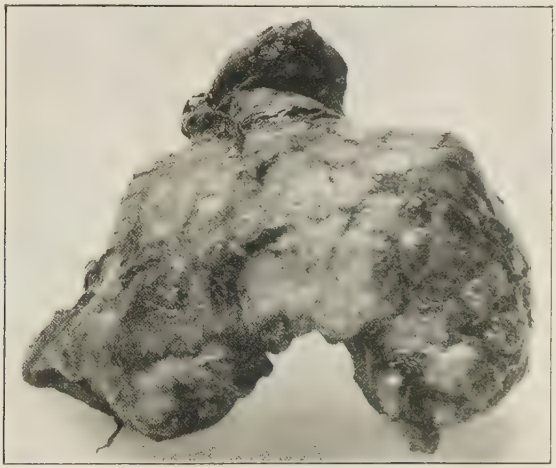


FIG. 117.—This is the back view of the preceding specimen. It shows the position occupied by the vesical sphincter as cross striations with a considerable bulging beyond its upper margin.

Adenomatous Hypertrophy.—Adenomatous hypertrophy of the prostate is most frequently found in both the lateral and the middle lobes, the anterior lobe being affected in a few rare instances, 4 times in

our experience. The posterior lobe is practically never the seat of this type of lesion. If a portion of the gland protrudes into the bladder it will usually be found to be the group of subcervical tubules, and these

FIG. 118.—This specimen was obtained at autopsy. Several years before death from pneumonia the patient's retention of urine, due to enlargement of the subcervical group of tubules, was successfully relieved by means of the galvanocautery apparatus.

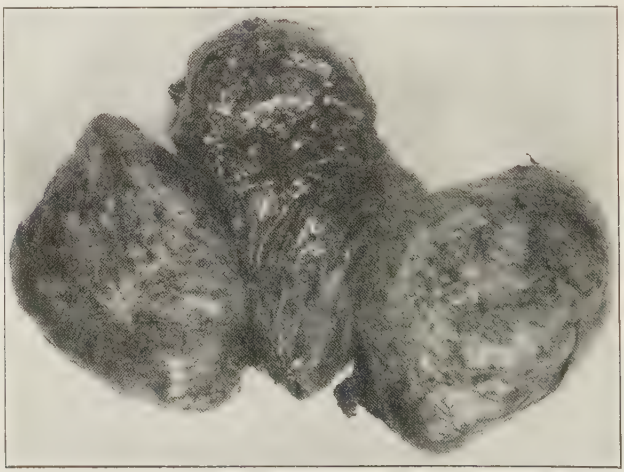


FIG. 119.—True middle lobe enlargement of the prostate, with a subcervical group enlargement embedded in it.

can be identified microscopically by the slight tendency of the mucosa to become heaped up and to project into the lumina of the tubules, which are lined with many layers of cuboidal epithelium instead of a single layer of cylindrical epithelium such as forms the lining of the

prostatic tubules. A further point of identification is the absence of the muscular envelope found in the tissue of the prostate proper. Rarely there will be an intrusion of the middle lobe, and when this is the case the trigonum vesicæ will be thinned out and the vesical sphincter so lifted up and attenuated as to be practically obliterated. Frequently the subcervical group will be found embedded in the middle lobe. The lateral lobes may also intrude in a similar manner.

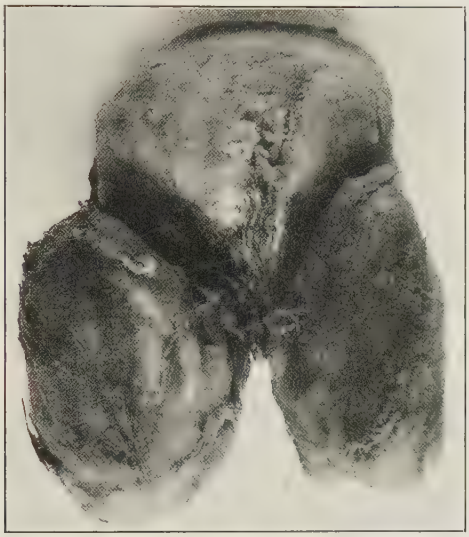


FIG. 120.—Very great true enlargement of the middle lobe of the prostate gland.

Types of Hypertrophy.—Considered microscopically, several types of non-malignant prostatic enlargement may be distinguished: (*a*) The most common type is that characterized by a dilatation of the tubules which are lined with a single layer of tall cylindrical cells with their nuclei near their bases. Usually the lumina show an intrusion of the mucous membrane in the form of papillary projections due to the proliferation of the mucosa. Frequently the lumina are so distended and the amount of interstitial tissue between the tubules so limited that the epithelial cells will be found on membranes which lie back to back, with neither muscular nor connective-tissue cells intervening. This process is commonly called "bridging," and has hitherto been explained by the statement that the mucosa has grown across and become joined to that upon the lumen's other side. The thinning-out process, which is due to great distention of the tubules' individual branches, in our opinion offers a more rational explanation of this phenomenon.

(*b*) Further extension of this process results in cyst formation; usually the cysts are of small size, but occasionally are large enough

to occupy a full half of the enlarged prostate. In a case observed by one of us, when the lateral lobe was opened most of the tumor dis-

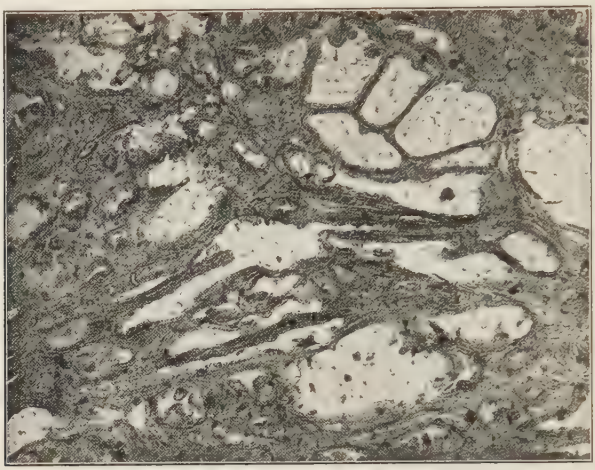


FIG. 121.—Photomicrograph showing the cystic type of prostatic hypertrophy with the so-called bridging of tissue. This bridging is due to a dilatation of the tubules with a thinning-out of the fibrous tissue between, and not due to an outgrowth of the mucosa and actual joining with tissues of the opposite side, as was formerly thought. These tubules are lined with a single layer of columnar epithelial cells with the nuclei near the bases.

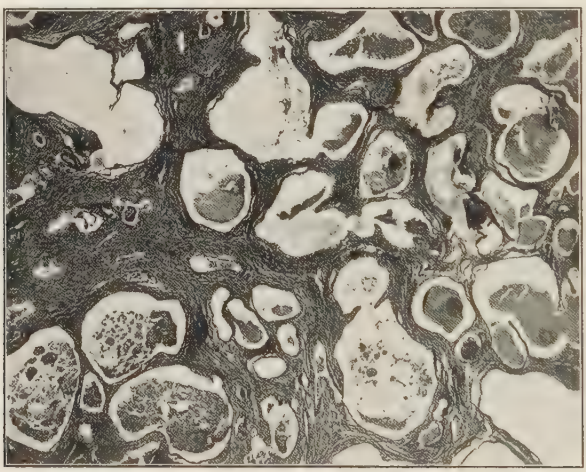


FIG. 122.—Cross-section of cystic type of prostatic hypertrophy. The tubules are seen to be filled with detritus, as well as the mucosa, which has entirely separated from the basement membrane.

appeared; surrounding the groups of dilated tubules and their branches there was a layer of tissue of varying thickness, mostly fibrous,

although occasionally considerable smooth muscular tissue may be demonstrated when stained by Van Giesen's method.

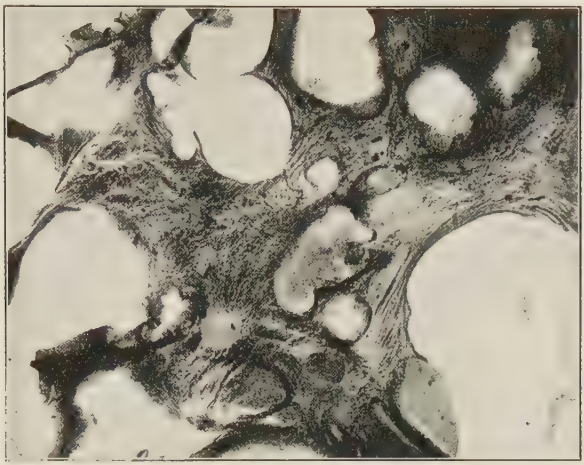


FIG. 123.—Photomicrograph (high power) showing cystic type of prostatic hypertrophy. The mucous lining has disappeared from this specimen.

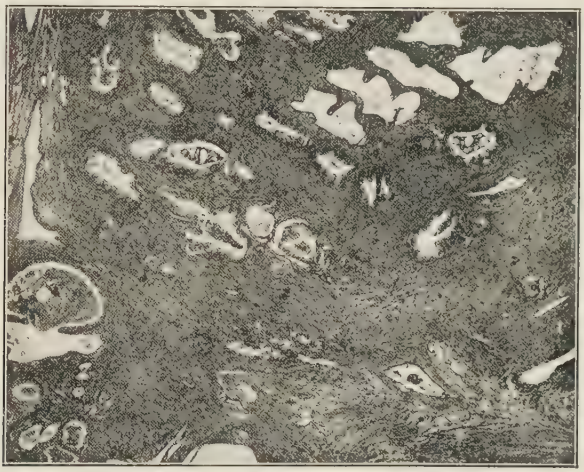


FIG. 124.—Photomicrograph showing the fibrous type of prostatic hypertrophy. The tubules are compressed and inconspicuous.

(*c*) The fibro-glandular type appears when an unusual amount of fibrous tissue has been laid down. If this process is very intense there will be a large increase in fibrous connective tissue or smooth muscle fibers or of both, which will produce (*d*) the fibrous type, with more or less compression of the tubular elements, which will not then display the granular hyperplasia observable in Group *a*.

Evidences of chronic inflammation will be found surrounding the acini in specimens illustrating any of the types just enumerated. Marked infiltration of small round cells will be observable near the basement membranes of the prostatic tubules. This increase in the cellular elements varies greatly in individual cases, and in some instances causes a marked induration. When a patient with an enlarged prostate refuses operation prostatic massage will occasionally bring considerable relief by reducing the amount of cellular elements and thus lessening the induration.

It has been recently remarked[47] that the much discussed question as to whether adenomata or fibromyomata predominate in prostatic hypertrophy, is really of little importance, as actually it is established that there really exists no pure formation of either type. The softer, so-called adenomatous type which is observed in about 90 per cent of patients may be considered as the rule, while the hard sclerosed nodules or the more generalized fibrosis, should rather be considered secondary inflammatory or congestive changes, produced by the presence of the growth or by other pathological processes which involve the prostate. Either type should be differentiated from primary neoplastic proliferation, which should always be regarded as a separate pathological entity.

Sarcoma.—An enlarged prostate in a child or youth should always suggest the possibility of sarcoma, as this is essentially a disease of early life, often being so extensive even when discovered in the first few months of life as to suggest prenatal origin. Socin discovered a case in a child aged eight months, the growth involving the entire pelvic cavity, though it had evidently begun between the bladder and rectum. Bree has reported a sarcoma in a nine-months' old infant and of the 31 cases reported by Powers, 3 occurred in children less than a year old, 12 of the remaining subjects were under eight years of age, 8 between fifteen and twenty-four, and only 6 of the "cancer age," that is between fifty and seventy. Gibson in 1909 reported 2 cases which he had personally observed and tabulated 37 other authenticated instances of prostatic sarcoma. Herrick[18] found that of 62 cases on record when he wrote in 1920, one-third occurred before the patient had attained the tenth year, three-quarters were below the "cancer age of forty," and 80 per cent before the usual age of prostatic adenoma, that is, fifty years. He regarded these observations as of great diagnostic value for a prostatic tumor occurring before fifty years of age is possibly sarcoma, and one occurring in adolescence is probably of such a nature.

Symptoms.—The most common symptom is obstruction either of urination or defecation, or of both. This stage is reached rapidly, usually occurring one or two months after the tumor is first observed. Sometimes the urinary symptoms are entirely lacking, but pain is always a constant feature, and quickly becomes so intense that these unfortunates usually pass the later stages of their disease under the influence of opiates. By rectal palpation the tumor will prove

firm and of uniform consistency, and with an elastic feel, described by Powers as "balloon-like." Frequently there is no tenderness whatever, and if this manifestation is present, it is only of moderate degree. The growth can be differentiated from a tubercular process in that the tuberculous prostate does not become as large as one which is the seat of sarcoma, and has a varying consistency, with small nodules or soft areas scattered through it. One or both of the seminal vesicles will ordinarily be found to be enlarged and nodular, and nodules may be felt in the epididymis or vas of the affected side. Other evidences of tuberculosis will probably be found if a proper search is instituted. Cancer of the prostate usually takes place later in life than sarcoma, and the gland will be smaller and present the well-recognized firm nodular consistency associated with that disease. The growth will be more irregular and fixed, and the unilateral sulcus very early obliterated. Carcinoma spreads beneath Denonvillier's fascia, while sarcoma is immediately and abruptly encountered by the examining finger. To quote Herrick: "The age of incidence, the rapidity of growth, the balloon-like feel of uniform consistency, the chief symptom obstruction to urination, strongly suggest sarcoma."

Metastasis to the neighboring lymph glands, to the lungs, the liver and the bones, are very common and occur early, being occasionally the first manifestation which directs attention to the existence of the disease. Surgical removal is seldom of much avail, as recurrence is almost certain, though a few cases of apparent cure have been recorded. The prognosis, especially in young children, is always most grave.[12]

Primary Lymphosarcoma.—Primary lymphosarcoma of the prostate, has been reported by Quinby[37] in 1920, and by Symmers[45] two years ago, who claimed that the case which Coupland reported to the London Pathological Society in 1877 was the only similar one on record. Symmers believes, however, that this type of growth is not so rare as the paucity of the literature would lead one to suppose and that lymphosarcoma should always be considered a possibility in patients under thirty-five years of age with prostatic tumors. The recognition of this type of growth in the prostate is peculiarly important in view of the favorable results that have been recorded by the roentgen-ray and radium treatment of lymphosarcoma in other parts of the body. Quinby remarks on the difficulty of diagnosis and that it seems characteristic of this type of growth that its local symptoms are either entirely lacking, or only made prominent by an intercurrent infection of the gland.

Carcinoma.—Carcinoma of the prostate is most frequently a primary growth, but may be a secondary implantation. Geraghty has pointed out that it begins in most instances, 49 out of 50 cases, in the posterior lobe, the particular part of the gland which does not participate in adenomatous hypertrophy. In the 73 cases of Wilson and McGrath, 51 (69 per cent) showed marked glandular hypertrophy, as was evidenced microscopically by papilliferous projections into the

acini. In 30 cases (41 per cent) there was definite muscular atrophy, and in 61 cases (83 per cent) the fibrous stroma was increased. In 10 cases (13 per cent) there was no evidence of associated hypertrophy in the sections from the glands which were examined, leaving 87 per cent in which there was evidence of hyperplasia. Whether in these cases the hypertrophy was primary and the carcinoma implanted thereon, it was impossible to determine, although in many microscopic sections the apparent transition by almost imperceptible variations from simple hyperplasia to undoubted carcinoma was observed.

Once established in the posterior lobe, the carcinomatous process extends upward to the base of the prostate where it involves the seminal vesicles, and it is only when it has passed the upper edge of the intervesicular fascia that it is able to invade the rectum, as this

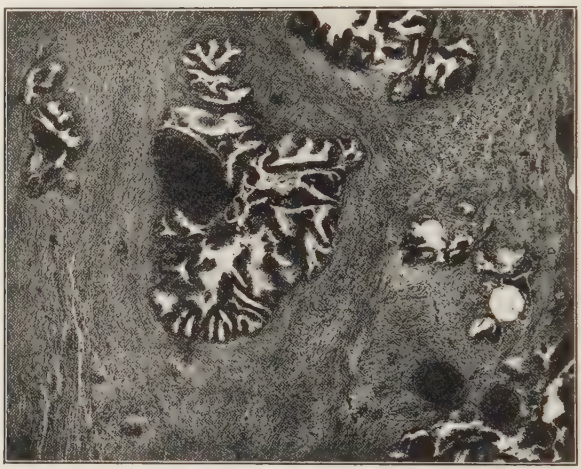
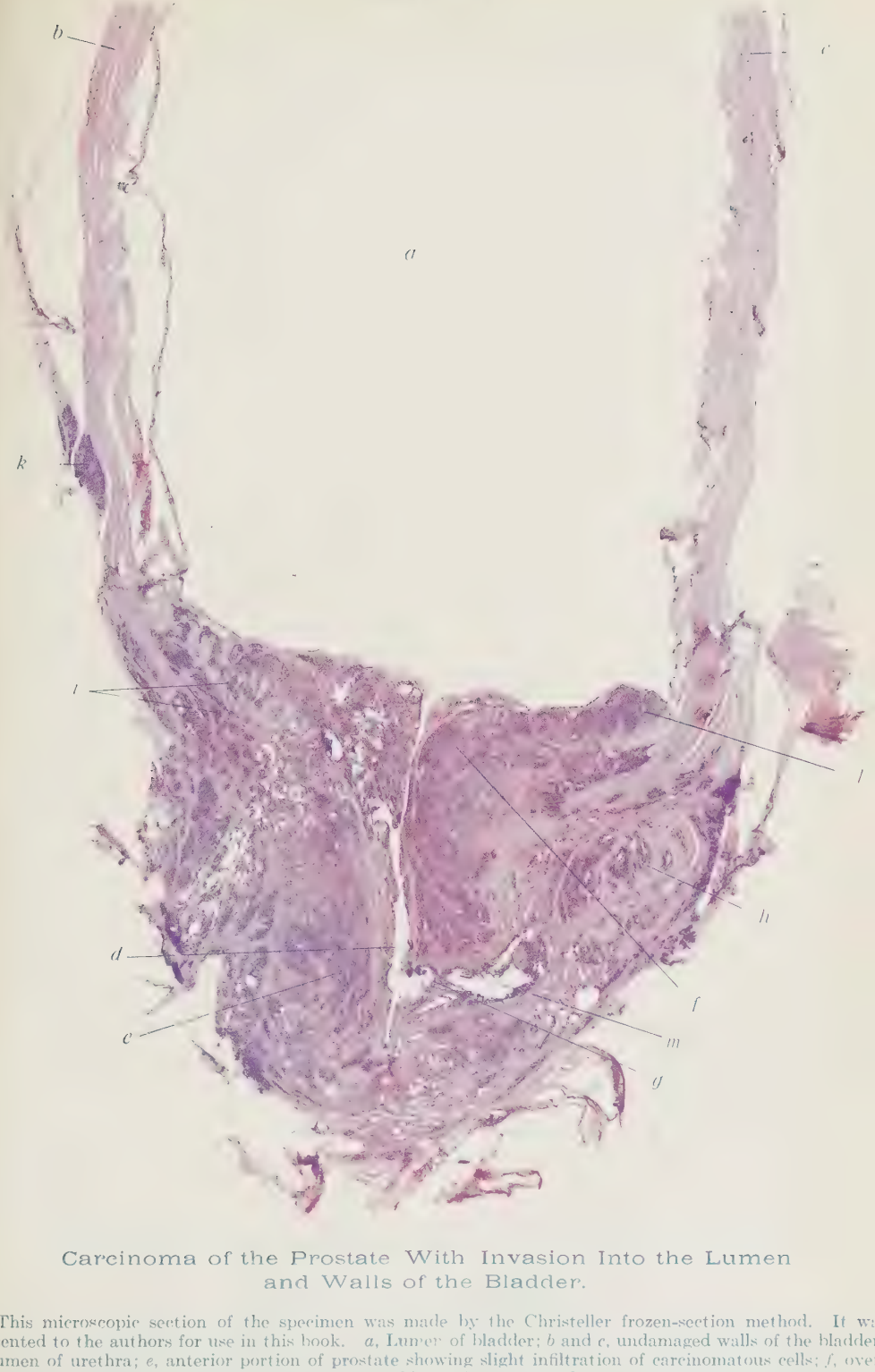


FIG. 125.—Photomicrograph showing overgrowth of the mucosa of prostatic tubules in hypertrophy of that gland. This condition is considered by some authors to be a precursor of cancer. Several corpora-amylacea are noted in the section.

structure is protected in the region of the prostate itself by the fascia of Denonvillier, the importance of which has already been pointed out. The lateral and middle lobes of the prostate are, of course, quickly involved in the malignant process, and metastases, especially to the bones, are usually of early occurrence.

Pathology.—The types of carcinoma most often encountered in the prostate are the medullary, although colloidal and melanotic growths have been observed and reported. Keyes has truly said that no amount of epithelial proliferation within the acinus is evidence of carcinoma of the prostate, for these changes may be brilliantly illustrated in simple prostatism. Wilson and McGrath describe a great variety of arrangement in the adenocarcinomatous tissues. The acini of the tumor may be small, numerous and closely crowded together with compressed



Carcinoma of the Prostate With Invasion Into the Lumen and Walls of the Bladder.

This microscopic section of the specimen was made by the Christeller frozen-section method. It wa resented to the authors for use in this book. *a*, Lumen of bladder; *b* and *c*, undamaged walls of the bladder , lumen of urethra; *e*, anterior portion of prostate showing slight infiltration of carcinomatous cells; *f*, over rowth of carcinomatous tissue well inside of the bladder neck; *g*, broken-down area in region of veru montanum , seminal vesicles showing carcinomatous involvement; *i*, musculature of the bladder neck showing carcinoma ous infiltration of ventral wall; *k*, extention of carcinoma into perivesical tissue; *l*, solid mass of carcinomatou issue on trigonum vesicæ; *m*, abscess cavity in the region of the ejaculatory duct.

cylindrical cells of the aberrant type, or they may be large and loosely filled with aberrant cells containing metachromatic nuclei. In most instances cancer cells infiltrating the stroma can be readily demonstrated. In medullary carcinoma the cells are relatively large, polygonal in shape, with a swollen chromatophilic nucleus. The cells are supported by a delicate capillo-vascular network. The scirrhus type shows infiltrating lines or groups of aberrant cells with densely staining nuclei scattered through a superabundant stroma. The stroma itself is frequently infiltrated with small cells containing densely stained nuclei and is apparently proliferating.

The hard tense structure of prostatic carcinoma was originally emphasized by Young and Geraghty,[59] who described the lack of a sense of elasticity upon pressure, and the "gritty sensation" imparted to the knife when cutting into one of these growths as if one were section-

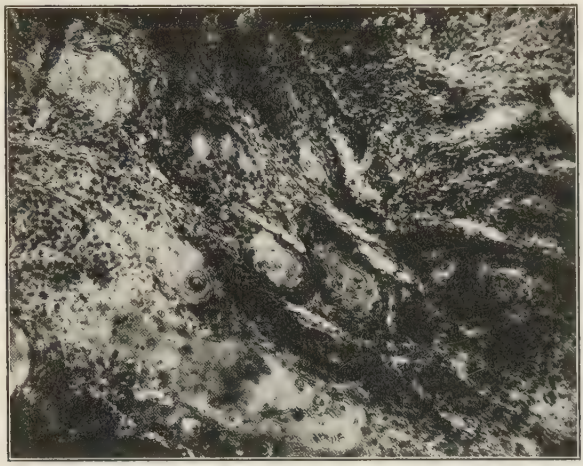


FIG. 126.—Photomicrograph showing pearls in epithelioma of the prostate gland.

ing cartilage. The finer details of the cut surface vary somewhat, irregularly interlacing bands of varying size are seen, with small grayish-yellow isolated masses scattered here and there. The interlacing bands are fibrous in character, and the yellowish areas, accumulations of cancer cells. This appearance is not present in fibroid prostatitis, in which the epithelial element frequently disappears, and in which the surface is much more smooth and homogenous than in cancer. Where cancer is infiltrating in character, fine yellowish lines can frequently be seen by the aid of a small magnifying lens. Usually one can be moderately certain of the cancerous nature of the tissue upon gross inspection alone. When the operator's knife, in making capsular incision cuts through tense tissue which does not bulge, the edges of which are firm and ridged, suspicion should be at once aroused.

PROSTATIC CALCULI.

Stones in the prostate are more likely to be encountered by the pathologist than by the surgeon, because they seldom give rise to symptoms and are only found when examination for some other pathological condition is being made. In the study of more than 250 prostates taken from subjects of all ages obtained in the routine necropsies at Bellevue Hospital, New York City, one of the authors found prostatic calculi embedded in a fairly large proportion of the glands; although no records were kept, the impression remains that at least a one-fifth of all the prostates examined contained one or more of these concretions. It is a very common occurrence to meet with calculi when sectioning an adenomatous prostate for microscopic study. Although their exact etiology is uncertain, they are supposed to be built up by a deposit of calcareous material in the corpora amylacea.

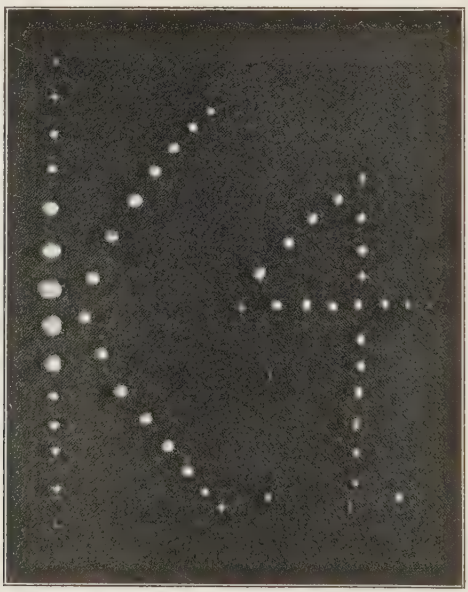


FIG. 127.—Fifty-four stones removed from the prostate of a man aged forty-eight years, and artistically arranged by the Bellevue photographer.

Symptoms are often wholly lacking, in fact prostatic calculi as a rule, are quiescent, only occasionally giving rise to abscess formation and subsequent manifestations of such a condition, or still more rarely, being evacuated after prostatic massage has been practiced. Rectal examination and roentgenograms, if systematically carried out with that end in view, would doubtless reveal many more of

these concretions than we at present expect to find. One of our patients complained of difficulty in urination, but apparently suffered no other inconvenience from the 325 stones which were later removed from his prostate. Another patient had a collection of 125 stones.

Historical.—Up to a short time ago the possibility of calculus formation in the prostate was only rarely considered, or was ignored entirely. Even in the present century such eminent urologists as Legueu and Marion stated positively that the existence of prostatic calculi was doubtful, and even if they were occasionally present they were of no clinical importance. But in the last ten years we have had at least two good reviews of the whole subject—that of Glaesel[17] in 1914, and a most excellent article by Kretschmer[22] in 1918. Before Glaesel's article appeared prostatic calculi were thought to be medical curiosities, but he was able to collect 54 reported cases and Kretschmer brought the number up to 173, remarking that "doubtless many cases have been overlooked." A translation of the historical review given by Glaesel is of interest:

FIG. 128.—Enlarged lateral and middle lobes of the prostate. The prostatic urethra contained a phosphatic stone covered with dark-brown crystals. This is called a false calculus.

"It is at the end of the sixteenth century that the first reports of stones in the prostate are to be found. Before that time one can find no definite reports. Marcellus Donatus in 1586 published the history of a case in which a stone was found in the prostate of a man who complained that when he attempted sexual congress he could ejaculate only a little watery sperm. At the beginning of the eighteenth century Jacob Douglas published a description of a hard substance about the size of a pea, which was taken from the prostate of an old man. In 1737, thirty years thereafter, the first really accurate account

of this prostatic disease was given by Pohl, and after this we find more generally correct accounts of these concretions, one by Louis in 1747, and in 1762, Morgagni's account of the corpora amylacea, which is even yet a classic on this subject." Home (1811), Amusat (1832) and Marcet (1833) also mention prostatic calculi.[11] The summary ends with a quotation from Civiale (1838).

Primary and Secondary Calculi.– A distinction is made between true and false prostatic calculi. By "false" calculi are meant those which are actually located in the prostatic urethra and not in the gland itself. Primary prostatic calculi, to employ Kretschmer's distinction, are those having their origin in the prostatic tissue. They consist in the main of phosphates, carbonates or oxalates of lime, or magnesia or triple phosphates. Lassaigne whom Glaesel cites, gives as the composition of primary stones:

	Per cent.
Calcium phosphate	84.5
Calcium carbonate	0.5
Organic material	15.0

It is pointed out by Kretschmer that secondary prostatic calculi can be differentiated from the primary by their chemical composition, their nuclei being composed of urates and earthy phosphates. The difference between primary and secondary calculi must rest upon the chemical examination of their nuclei, for secondary stones may have an outer covering similar in composition to that of true calculi.

Symptoms. So frequently do these stones remain in the prostate for long periods without giving any symptoms, that they are more often found when examination or operation is undertaken for some other pathological condition in the uro-genital tract. Even when the patient comes under observation because calculi are suspected or have been demonstrated, the symptoms are so far from being characteristic that diagnosis can scarcely ever be made by consideration of the clinical history only. Our surest means of diagnosis is radiography, and it seems strange that in so comparatively few instances is this readily available diagnostic aid invoked. The most important symptoms due directly to the presence of stones in the prostate are pain, the actual passage of calculi, either following massage or spontaneously, and occasionally the formation of an abscess, with the possible sequel of fistula. When the stones pass out by way of the urethra they may be confused with urinary calculi, and no doubt often pass wholly unnoticed, as they are seldom large enough to cause obstruction. (Fig. 129).

Diagnosis. *Rectal examination* may yield important evidence in the diagnosis of prostatic calculi. As with similar formations elsewhere located, crepitation can often be elicited, but the inability to produce it does not necessarily rule out the possibility of stones being present. If the stones have attained a sufficient size they can usually be detected by palpation of the rectal wall. The likelihood of their being passed

after prostatic massage has already been mentioned. Another point stressed by Kretschmer is that there may be great induration of the entire prostate gland, so that it feels as "hard as a stone." Therefore increased consistency of the prostate during early adult life should arouse one's suspicions for the possibility of the presence of calculi, whereas in older persons, increased consistency may be significant of malignancy.

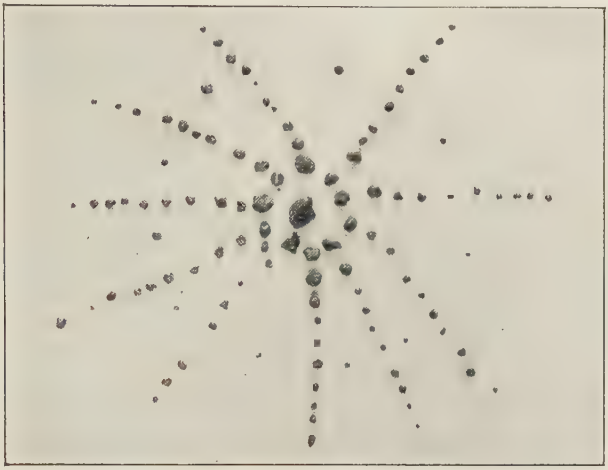


FIG. 129.—One hundred and nine stones removed from the prostate of a young man aged thirty years, without removal of the gland. Per rectum this prostate was enlarged, nodular and very hard. The diagnosis was easily made by the crepitation detected. These calculi cast a shadow on the roentgen-ray plate.

Treatment.—The measures necessary for the relief of this condition will be discussed fully in the section on surgery of the prostate. If the calculi are very small, producing no symptoms, and only observed when a routine roentgenographic examination is being done for some other condition, it is usually best to leave them alone. Removal with the endoscope, or the attempt to evacuate them by massage have not proved of lasting value in the majority of cases. Recurrence is very common when these methods have been practiced.

SURGERY OF THE PROSTATE.

Preoperative Care.—In no branch of urological surgery is the preoperative preparation of such importance as in interventions upon the prostate, more especially prostatectomy. Unless the surgeon gives this phase of the case his immediate personal attention, it is altogether likely that his best surgical skill will be of little avail, so much does the final outcome of the operation depend upon the general physical condition of the patient at the time he undergoes it. The first time

a prostatic patient comes under observation he should be given a most thorough general physical examination, in addition to rectal palpation, an estimation of the amount of residual urine, and the performance of cystoscopy to determine the exact nature of the glandular enlargement. It is only by cystoscopy that a comprehension of the extent of the intrusion of the enlarged prostate into the bladder and the urethra can be gained, for the mere size of the gland as felt through the rectum cannot be taken as a criterion of the extent of the obstruction it is capable of causing. In general, it may be stated axiomatically that where there is little or no residual urine, the prostate should not be extirpated, no matter how large it may appear by rectal palpation.

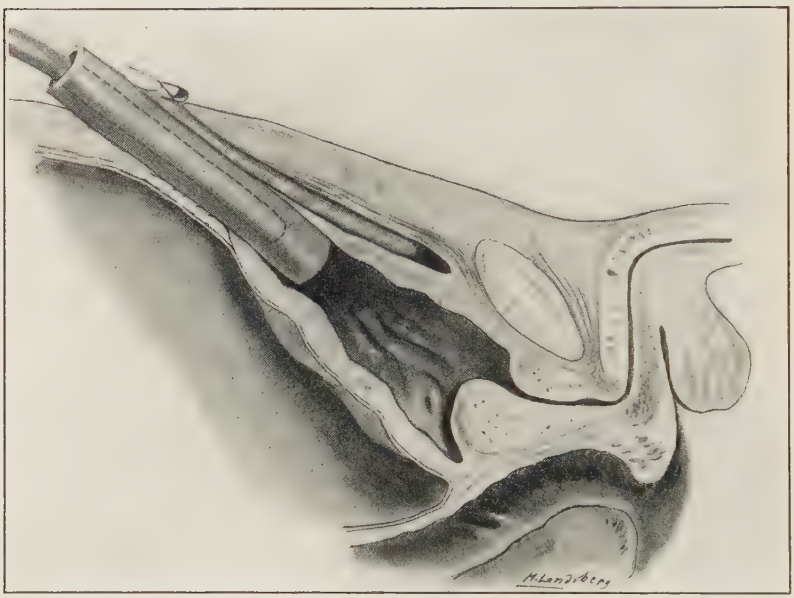


FIG. 130.—The double suction tube, devised by Kenyon at the New York Hospital many years ago, is shown in position at the highest point of the bladder, passing obliquely through the abdominal wall. The small inner tube, being connected with a vacuum bottle, withdraws any fluid which arises in the large outer tube. The column of air between the two tubes prevents the wall of the bladder from being drawn up into the tube. There is a cigarette drain inserted into the space of Retzius which is removed twenty-four hours after operation. This method of drainage is effective and painless.

Drainage.—Drainage is the most important part of the preoperative regime. It should be instituted as soon as the patient comes under observation, but should at first be intermittent. As has been already pointed out (page 60) when complete retention has occurred, care should be exercised in emptying the over-filled bladder, as it is possible to induce uremia by a too sudden evacuation of the entire vesical content. It is best to irrigate and partly refill the bladder with boric acid solution, repeating the process at intervals. If the patient bears

intermittent catheterization well, this may at first be employed, but later continuous drainage should be practiced, either using the retention catheter, or better still, doing a suprapubic cystotomy under local anesthesia. It has long been our practice to use this method of

FIG. 131.—Typical surface appearance of a distended bladder due to retention of urine from prostatic enlargement. The globular mass is seen extending above the umbilicus.

draining the bladder in preference to continuous catheterization, for the passage of the instrument is almost sure to result in trauma, no matter how carefully it is done, which will exacerbate the vesical inflammation practically always in evidence at the time the patient first comes under observation. The prostatic patient is not very tolerant of the indwelling catheter, at least in our experience, and its use is likely to produce acute cystitis, epididymitis or urethritis. Moreover, the average patient finds catheter drainage so distressing that the discomfort it causes is likely to more than offset any advantages which may accrue from its employment.

In our service at the New York Hospital we have found drainage by suction and the double tube to be as nearly ideal as is possible to attain. After the fourth or fifth day the patient is placed in a chair, perfect drainage being effected without any of the annoyance which accompanies the suprapubic siphon method, or either intermittent or retention catheterization. It is just as essential to keep these old men clean, dry and comfortable as it is to give proper nursing care to little babies, and they respond to it almost as readily. Neglect an old prostatic, leave him wet, unwashed and without proper nourishment, and he will die almost as quickly as a neglected infant.

The length of time drainage should be carried on depends altogether upon the individual case, and should never be regulated by any fixed routine. It should be continued until the patient has attained his maximum of renal efficiency, and this can only be determined by the results of the following tests, comparisons of which should be made before the preliminary operation, and at frequent intervals thereafter:

(*a*) Urea in a twenty-four hour specimen in order to determine the amount being excreted.

(*b*) Blood-chemical tests to determine the amount of blood urea, of non-protein nitrogen, and of creatin retention; also the acidity of the blood.

(*c*) Last of all, a color test to ascertain the activity of the renal epithelium; the most helpful drug in this connection is phenolsulphonephthalein, and second to that indigo-carmine. Other tests which may be employed are the Mosenthal concentration test, cryoscopy, or the estimation of various substances excreted, such as potassium iodide, sodium chloride, etc.

Personal Considerations.—In our zeal for scientific exactitude, we must not forget that the patient is first of all a human being, and must be treated as such. Not until he has reached a condition where he he can face the ordeal of operation with cheerfulness or even eagerness, must we consider him fit to undergo it, even if his renal function is all that can be desired and the results of all other tests and examinations are entirely satisfactory. His diet should be as varied as possible, although meat and alcohol must be interdicted, and fluids imbibed in large quantities. Fish, poultry and sweets in moderation can be given unless some special contraindication exists.

Medication.—Urinary antiseptics should be administered until twenty-four or forty-eight hours previous to operation. If well borne, hexamethylenamin in 10 or 15 grain doses is very suitable for this purpose. One hour previous to its administration an acidifying agent such as acid sodium phosphate or sodium benzoate should be given to the patient. Sodium bicarbonate by mouth or by rectum in a 5 per cent solution should be administered for seventy-two or forty-eight hours before the operation is to be performed. Whatever purging is considered necessary is better carried out the day previous, for in this way the night immediately before the surgical intervention will be one of undisturbed rest. The lower bowel can be emptied by enemas an hour or two before going to the operating room.

On the day of operation there should be a final "going over" of the patient's entire body, and thoughtful consideration given to his general manner and appearance; a close inspection made of his head, particularly the eyes and tongue; his chest, abdomen and extremities examined, and a careful review made of his temperature chart, pulse-rate record and blood-pressure comparisons.

The advantages of such a course have been repeatedly exhibited to us in the course of our urological work. On one occasion a patient appeared in prime condition for his prostatectomy, which was arranged to take place the following day. The routine phenolsulphonephthalein test on this last day, however, showed such a low percentage, verified on repetition, that despite all reassuring evidences to the contrary, we decided to postpone the operation. Within a few hours there was a rise of temperature, and pleurisy shortly thereafter developed. The operation was later successfully carried out. In another instance, a final blood-chemical examination demonstrated a condition bordering on acidosis, and it was necessary to delay operation for several days until sufficient sodium bicarbonate could be adminstered to relieve the condition, after which prostatectomy was performed without mishap.

Anesthesia.—Next in importance to giving the subject of every intervention upon the prostate the preoperative attention which has been outlined in the preceding paragraphs, is the selection and administration of the anesthetic. It is not too much to say that on these two contributory factors the entire success of the operative procedure in great measure depends; if they be neglected or inadequately carried out, the greatest surgical skill can hardly avail to counterbalance the omission.

Choice of Anesthetic.—We feel that it would be impossible to overestimate the importance of choosing the proper anesthetic, and the relative merits and disadvantages of each type as applied to the requirements of this particular branch of surgery should be most carefully considered. Of the use of chloroform it is hardly necessary to speak; that its employment is absolutely contraindicated in interventions upon the prostate or indeed, in urological surgery in general, is so

commonly accepted by the medical profession at present, as to make it unnecessary to include it in any such discussion. A few years ago chloroform was recommended for use in cases with advanced pulmonary lesions but relatively sound cardio-vascular systems, but our knowledge of what to do under these conditions has been so greatly augmented during the past few years that this decidedly dangerous drug can now be altogether banished from prostatic surgery.

Ether has never proved very satisfactory because of its irritating effects, and gas-oxygen anesthesia, although extensively used, has the property of raising blood-pressure most undesirably, with resulting likelihood of shock and hemorrhage. Ethylene gas is open to the same objections.

Regional Anesthesia.—The induction of anesthesia by means of procaine and similar drugs paravertebrally administered, is rapidly proving itself the method of choice in the vast majority of urological operations, and in none is this more true than when the prostate is the site of the surgical intervention. Our results following the use of this anesthesia have been so eminently successful that we are coming to depend more and more upon it, recently reporting a series of 250 major operations successfully carried out under regional anesthesia alone.

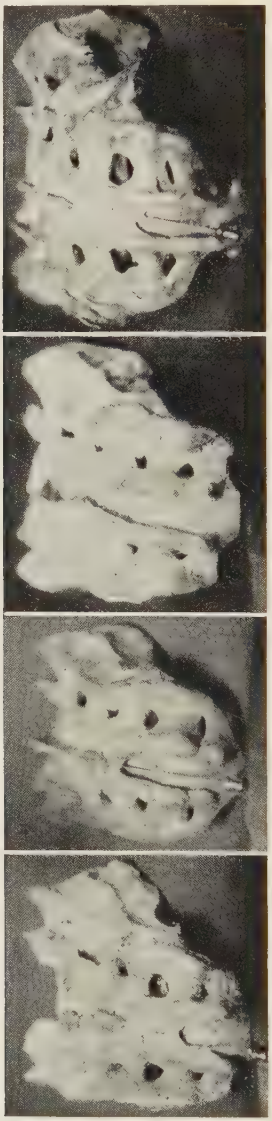
Parasacral Anesthesia.—Anesthesia by the parasacral route is a fairly recent acquisition in surgery of the uro-genital tract. We are indebted to the neurologists for the initial use of the method, for injections into the caudal end of the spinal cord were first successfully carried out by F. Cathelin and Durant in 1902, when they introduced various substances in the treatment of sexual neuroses, incontinence of urine, and other disturbances of a neurotic nature. The method was first applied to surgery of this region eight years later when A. Läwen employed it in 1910. Improvements in the media used and the methods of employment have been published by O. Gros, Lewis and Bartels, Pickens, Thompson, Harris, Scholl, and Labat. Paravetebral block anesthesia has received its greatest impetus in urological surgery from its employment at the clinic of Professor Illyes in Budapest, where Snitzer alone has used it in more than 1600 surgical operations. As the use of this method had its origin in Central Europe, it has naturally been there that it has been accorded the widest recognition, but in the past few years Pauchet, Duvergey and other French surgeons have taken it up, Duvergey especially having been highly successful in its use, so that he is today one of the most enthusiastic supporters of the paravetebral method. In this country Farr, Lowry and Meeker have been, so far, among the very few who have given much attention to the method as applied to urological surgery, but we feel safe in predicting that once its merits become known to the great body of American surgeons, its use will shortly become very general.

Methods of Administration.—After the prostatic patient has passed through the routine of preoperative treatment which has already been described, and has reached the time set for operation in a general physical condition which gives promise of success for the intervention, one hour before going to the operating room, he receives $\frac{1}{8}$ grain of morphine in 2 cc. of chemically pure magnesium sulphate, given hypodermically after the method of Gwathmey. After thirty minutes, the dose is repeated, and if the previous dosage is not sufficiently effective, a third injection is given just as the patient starts for the operating room, or hyoscine $\frac{1}{300}$ grain may be substituted. It has been our practice of late to omit the use of morphine in all except the most excitable patients.

FIG. 132—The needle, with syringe attached, is inserted into the sacral hiatus and outside of the dura. Injection of procaine over the sacral foramina on each side is shown. After a sufficient quantity of the procaine solution has been injected into the sacral canal, 2 or 3 cc. is introduced into each of the sacral foramina, thus producing anesthesia of that portion of the perineum which sits on a saddle, and a cone-shaped area extending inward, including the neck of the bladder and its floor.

Upon his arrival the patient is placed upon the table, resting either upon knees and elbows, or upon the abdomen. The skin at the point where the needle is to be inserted is sterilized in the usual manner, and then infiltrated. The operator palpates the coccyx and sliding his finger above this bone, reaches the lower part of the sacrum, where he is usually able to palpate the sacral hiatus without difficulty. The sacral horns adorn the lateral borders of a triangle of which the hiatus is the apex. A 6-inch needle is inserted in the anesthetized skin and

into the sacral canal by puncturing the ligament which covers its lower end. After penetrating this ligament the needle is easily pushed in $1\frac{1}{2}$ to 2 inches, deflecting it and guiding it carefully so as to avoid



a *b* *c* *d*

FIG. 133.—(*a*) This sacrum shows the usual location of the hiatus. (*b*) This sacrum has its hiatus very high up—a common anomaly. (*c*) The roof of this sacral canal is entirely lacking. (*d*) The hiatus of this sacrum is so compressed that a needle can barely be introduced even when it is entirely freed from all organic matter.

impinging upon the bone. One learns to tell whether or not the needle is in the canal by the ease with which it passes and the direction which it takes. Should it pass just over and to one side of the canal roof,

the error will be detectable by observing its direction and the fact that it passes with difficulty. Also, if it is improperly inserted, no sooner will the injection be started than the tissue at the end of the needle will infiltrate with the solution. There is great variation in the sacra of different individuals and a careful study of the osteology, as well as the course of the nerves, is a necessary preliminary investigation.

The needle having been inserted into the canal, its end should be carefully observed to see if either blood or spinal fluid runs out. In the event of the former complication the needle is withdrawn to a point where the blood ceases to appear, and the injection made at that point. Should spinal fluid run out, the injection must be postponed until another day. But if the fluid runs in easily, it gives assurance that the canal has been entered. Should there be difficulty in making the injection however, it is an indication that the needle has not penetrated the canal, and the tissues over the sacrum should be observed for evidences of infiltration.

Solution.—The solution used in our work is freshly prepared procaine solution, 30 cc. of a 1 per cent solution being injected into the canal without the addition of any other chemical. We do not use adrenalin in the solution as we believe it adds to its toxicity.

Amount.—The injection into the canal is extradural and is presumed, under the pressure used, to elevate the dura from the bone. Provided the solution is not toxic it will be safe to employ a quantity up to 60 cc. The next step is to inject a 1 per cent solution of procaine into the first, second and third sacral foramina on each side, in accordance with the method of Labat. There will be little difficulty in locating the foramina if the needle is passed into the depression just below the transverse processes, and if it is pointed mesially and slightly upward, they will ordinarily be entered without trouble. From 3 to 5 cc. of 1 per cent procaine solution should be injected into each foramen, the needle being slowly withdrawn, so that it may be distributed throughout the entire depth of the cavity. The fourth and fifth sacral foramina may also be injected.

Length of Time Required for Anesthetic to take Effect.—The patient is placed on his back, and full thirty minutes allowed to elapse before the operation is begun. By this time that part of the body which would rest upon the saddle, were the patient on horseback, including the scrotum, urethra and base of the bladder, should be thoroughly anesthetized; otherwise the injection is unsuccessful.

We have found that if the operation is started too soon, the patient will often think that he feels pain and be in such an apprehensive state of mind that every movement of surgeon or attendants will cause him to complain. But if all activity is delayed until thorough anesthesia has taken place, he will go through the entire procedure without a protest. It is of the utmost importance to gain the patient's confidence before beginning to make the injection, and having assured him that he is to be caused no pain, the surgeon should live strictly up to the letter

of his promise. All suggestion of haste or excitement should be sedulously suppressed, all unnecessary display of instruments or other appurtenances of surgical procedure avoided, and an atmosphere of ease and tranquillity preserved just as far as is possible throughout.

Indications for Operation.—The most common reason for performing prostatectomy is the existence of fibro-adenomatous hypertrophy. The enlargement which is removed in performing the operation is enucleated from the gland in much the same manner that an adenoma is removed from the thyroid or a fibroid tumor from the uterus.[6] Often the fibro-muscular elements predominate, so that the glandular elements are practically non-existent, and a rigid ring encircles the neck of the bladder, with evidences of great induration of the entire region; the presence of such a condition is an equal indication for extirpation of the organ. Malignancy, already discussed on page 430, is still another indication for removal of the prostate gland, although in the presence of sarcoma the wisdom of operative interference must be carefully weighed in each individual case, as frequently no surgical measures will serve to prolong the patient's life.

Methods of Enucleation.—As has been indicated in discussing the history of the operation, prostatectomy may be performed by either the suprapubic or the perineal route. While the choice of the route is often a mere matter of preference with the individual operator, circumstances may very readily arise which will make it imperative for him to employ one or the other. Deaver has said that the hard small fibrous prostate will usually be very difficult of access by the suprapubic route, while the adenomatous organ will at times be so bulky as to absolutely prevent its removal through the perineum, except by fragmentation. Where the organ is fibrous and where periprostatitis (which usually accompanies the development of this variety) has existed, the adhesions between the prostatic capsule and its sheath are very dense, no natural line of cleavage exists, and enucleation is therefore difficult or impossible.

It is certainly most unwise for the urological surgeon to close his mind to the possibility of using any available type of operation. Moreover, it is perfectly possible by using the cystoscope, or by digital examination at the preliminary suprapubic cystotomy, to decide intelligently whether the hypertrophic gland should be removed by the suprapubic route, or through the perineum. But unless there is some very excellent reason for taking out the gland suprapubically, it is in our opinion preferable to perform the perineal operation because, while it requires more time and a very thorough knowledge of the anatomy of the region, it is not so likely to induce shock. Shock is liable to accompany intervention by the upper route because there is always more or less pressure and traumatism to the complicated nervous plexuses over which the work must be done; the effect being similar to that of the solar plexus blow, made familiar to the general public by the nomenclature of boxing. The possibilities of gravity

drainage, together with the fact that it is possible to permit the patient to sit up in a chair by the third or fourth day, a great advantage in aged patients especially, are additional arguments in favor of the perineal operation along the technical lines established by Young, or the excellent perineal operation of Voelker of Halle, and Sims of New York.

FIG. 134.—Suprapubic enucleation of the prostate. The index finger of the right hand is inserted into the prostatic urethra, which may be pushed up somewhat by the index finger of the left hand in the rectum. The superior commissure is broken through and enucleation carried on by working the finger, first in one direction and then in the other. This maneuver separates the two lateral lobes, the middle lobe and the remains of the anterior lobe from the capsule and the posterior lobe, which is divided from the rest of the prostate by a lamella of tissue in which are embedded the ejaculatory ducts in their passage through the prostate. Careful observation has shown that the posterior lobe rarely, if ever, takes part in hypertrophy of the prostate. Its tubules usually become compressed and cannot be distinguished macroscopically.

Suprapubic Enucleation.—Suprapubic enucleation has been described by Hinman[19] as a one-piece removal performed in one of two ways, intra-urethrally or extra-urethrally although the hyperplastic mass is often removed in separate pieces either way, he himself having preformed intra-urethral enucleation *en masse* by forcing a finger back into the urethra and tearing it anteriorly. By blunt dissection of this line of cleavage, the hyperplastic mass is freed from within outward. An annular or linear incision of the mucosa over the intravesical mass

may be used as an entering wedge for extra-urethral enucleation, from within outward, and although more difficult, this procedure would seem to be a method better suited to surgery, and probably more often brings about complete extirpation. Whenever the gland is not brought away in one piece, it is sometimes difficult to determine whether spheroids remain, even with bimanual palpation with the finger in the rectum, which few surgeons practice because of danger of sepsis. Any of these procedures must be performed through the internal sphincter, which is thereby dilated and sometimes destroyed. The supramontane portion of the prostatic urethra is torn or more commonly completely removed. Tags and flaps of mucosa are generally left at the prostatic margin or cavity. The prostatic cavity is packed for hemostasis, thus tending to perpetuate posterior urethral elongation and cavity formation.

Perineal Prostatectomy.—These and other considerations have influenced us in the great majority of our prostatic cases to employ Young's perineal operation, following the modified technic suggested by Hinman with certain modifications of our own as well. In this operation both internal and external sphincters are uninjured; the verumontanum with the ejaculatory ducts are carefully preserved and the vesical mucosa receives no injury. The prostatic capsule is packed lightly with one piece of inch packing which is removed eighteen hours after operation, and the tongue-shaped piece of capsule is not sutured back in position because it resumes its proper place, by pressure from the rectum, forming the floor of the urethra. The bladder is drained through the urethra with a large catheter or a small rectal tube. The floor of the pelvis is reconstructed by bringing the levator ani muscle together with a single catgut stitch, the skin being closed with silkworm-gut.

According to Hinman, cavity formation rarely follows the perineal operation, but structural defects at the vesical neck due to the presence of nodules or tags are common, and unless the operator is familiar with the perineal method, nodular remnants, resulting from incomplete removal of all the hyperplastic mass, are more likely to remain than after the suprapubic operation. These cause functional disturbance and may lead to recurrence of prostatism. Deep fissure or sulcus formation is also not uncommon, particularly in cases where very large glands have been extirpated, and in such cases likewise, mucosal plication may lead to obstruction to instrumentation as well as to urination.

Technic.—A Crowell tractor is inserted in the urethra, and the prostate exposed by the customary perineal approach. An inverted-V incision is now made through the posterior and median lobes, down to and including the posterior urethra, the highest point in the incision not extending beyond the apex of the prostate. The tongue-shaped piece of tissue thus outlined will include the verumontanum. This structure is now grasped with forceps, and a transverse incision made

in front of it and deepened in such a manner as to separate the middle lobe from the lamella of tissue which intervenes between the posterior

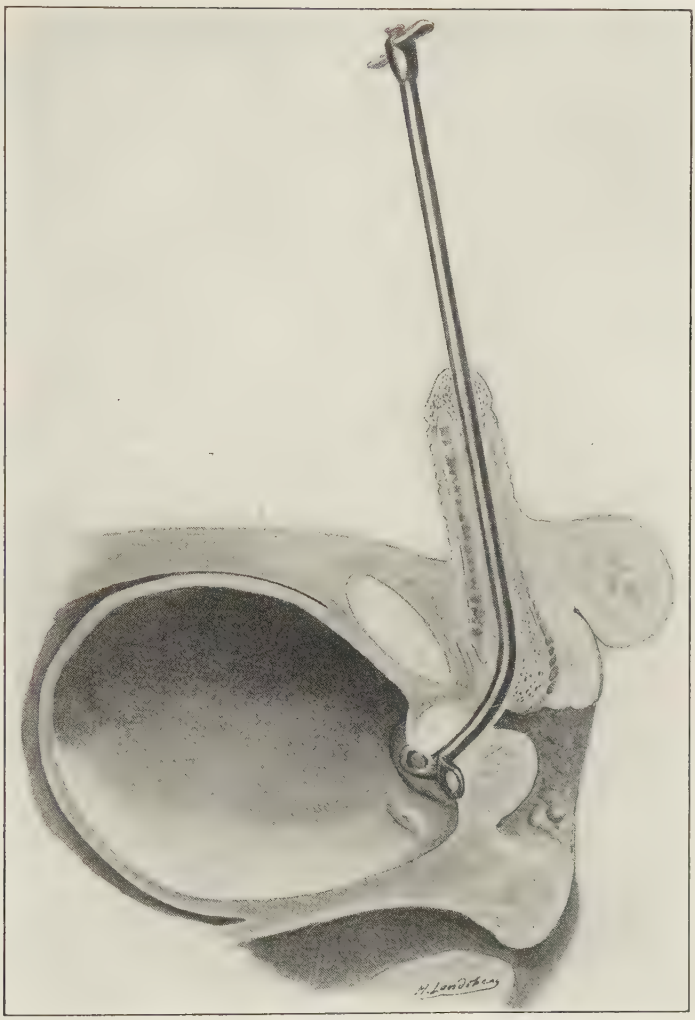


FIG. 135.—The Crowell tractor is shown in position being used in such a manner that the prostate is forced into the perineal wound. It acts very much in the same fashion as axis traction forceps do in obstetrics. Its particular advantage is that it does not cause pain by pressing on the symphysis pubis as does the straight tractor of Geraghty. The perineal approach to the prostate has already been shown in the pictures representing operation upon the seminal vesicles.

lobe and the remainder of the prostate, including the prostatic course of the ejaculatory ducts. The mass of the gland is then split at the anterior commissure, and enucleation can thereafter be accomplished

by blunt dissection in both directions. This procedure permits the removal of the hypertrophied gland consisting of both lateral and middle lobes, as a single piece.

Examination of the neck of the bladder both by eye and hand is now perfectly possible, and if any tags or small subcervical or intravesical lobes have been left behind, they can be cleared away without difficulty. A catheter on a stilet is passed through the urethra, the end of which is inserted into the bladder, the tractor having been removed. Through-and-through irrigation is provided for by inserting a second catheter through the perineum into the bladder. Light packing is placed about the catheters and the triangular flap of the posterior lobe, carrying the ejaculatory ducts and verumontanum, is replaced in position and secured by a mattress suture of chromic gut on the side opposite the gauze and catheter. An intra-prostatic gauze pack provides for cavity obliteration and hemostasis, and the wound is closed in the customary manner.

The advantages of this procedure are complete removal of the hyperplasia, without leaving a large prostatic cavity, with the preservation of both sphincters, the verumontanum and the ejaculatory ducts. If properly done there will be complete restoration of function in the great majority of cases. When sacral anesthesia is used, there is the additional advantage that the enlarged gland can be removed without infiltration of procaine directly into the operative field. There is much less shock than in suprapubic enucleation, because the patient is not subjected to the same amount of traumatism and pressure.

Postoperative Care.—Postoperative care should begin immediately the gland has been taken out. The wise surgeon stops hemorrhage before beginning to sew up the wound, and in the perineal procedure this is easily accomplished because the bleeding points can be seen readily, and are accessible to proper clamping and ligation. The cavity should not be packed too tightly for then the viscus will exert its recognized power of attempting to expel a foreign body, the resulting spasmodic contractions tending to keep up continuous hemorrhage. All steps to control hemorrhage should be taken at this time, for it is a vain hope that further packing or other manipulations will serve to put a stop to any bleeding which might begin later. The additional pain and disturbance which this would cause, might, together with the increased loss of blood when the blood-pressure is already lowered, induce a state of profound shock, very easily fatal.

The patient should be kept dry and warm and carried to his bed as quickly and quietly as possible. Blood-pressure observations should be made every two hours or oftener, until the circulation has passed entirely through its period of depression and is again at a safe level.

Postoperative Shock.—Postoperative shock is induced by loss of blood, with subsequent pain and injury to the nervous system. The use of regional anesthesia has lowered the incidence of this complication among our own patients, almost to the vanishing point. The

ordinary methods of combating shock are perfectly understood: raising the foot of the bed, warmth, administration of stimulents and fluids by mouth and rectum, with intravenous salt solution to raise blood-pressure. The most satisfactory method of maintaining blood-pressure, however, is, at least so far as our experience goes, the use of gum glucose solution intravenously administered.

Gum-glucose Solution.—The physico-chemical principles involved in the use of this intravenous medium are fundamentally as follows: Glucose being a crystalloid-like salt, it absorbs water through a semi-permeable membrane; the wall of the peripheral bloodvessel is a semi-permeable membrane. Tatum noted that in shock and following hemorrhage there was increase in the dextrose content of the blood, which he explained as an effort on the part of the organism to combat the existing pathological conditions. Hence the incorporation of the sugar substance with the acacia. The gum is a colloidal substance; in 6 per cent solution it represents a viscosity equal to that of the blood and the osmotic pressure of the blood colloids. Therefore the solution cannot leave the circulatory system, and what is more, will hold in the circulation the fluid that the crystalloidal glucose has attracted by osmosis. In other words, a crystalloid when introduced into the blood stream, passes rapidly into the cell tissues, and being non-oxidizable, rapidly reverses the process, with subsequent water-logging of the tissues.

Clinically, this may be expressed in terms of blood-pressure that is elevated and maintained for an average maximum period of thirty minutes by saline solution which at the close of this period will have left the circulation. Gum glucose, on the contrary will elevate the pressure and maintain it for a minimum period of three hours at the initial level with a slight subsequent fall, which however, seldom reaches the danger threshold.

Purpose of its Administration.—The idea in administering the gum glucose solution is to increase the volume of the circulation and to maintain it at this high level, thus raising the blood-pressure; to combat a tendency to acidosis; to furnish a certain amount of stimulation; and to supply nourishment. The injection of the fluid tends to increase the blood volume and to raise the blood-pressure. The presence of the gum in a certain measure prevents the loss of this fluid from the vessels and thus acts to maintain the advantage gained by the infusion; the glucose acts both to prevent or to combat the acidosis should this be in evidence; it also acts as a stimulant and furnishes some easily assimilable food to the body.

Technic.—In postoperative administration we have followed the practice worked out by Ward and Farrar of the Women's Hospital, New York City: Immediately following the beginning of the operation, an intravenous infusion of the gum glucose solution is started. It is allowed to run at the rate of not greater than 25 cc. per five minutes according to body weight. The temperature of the solution is main-

tained by hot-water bottles and regulated by a Bovee infusion thermometer. We are now using the Buckstein apparatus which simplifies the method considerably and facilitates the maintenance of the fluid at an even degree of heat. The injection continues throughout the period of the operation, during which it is seldom found necessary to give more than 30 cc. At five-minute intervals blood-pressure observations are made, which furnish a true index of the patient's condition.

Combating Postoperative Shock.—Infusions are sometimes extremely useful five or six hours after operation when failure of blood-pressure gives evidences of impending shock, shown by a subnormal temperature, pallor, cold clammy skin and sluggish or absent reflexes. Following the administration of the solution blood-pressure will be restored to a satisfactory level with marked improvement in the pulse-rate and volume, and in the general condition. The blood-pressure may subsequently fall from eight to twelve points but will rise again gradually within a few hours. Clinically there will shortly be noticed an increased diuresis accompanied by an increased desire for water; there will be no nausea and the passage of flatus will be accelerated. This last phenomenon was attributed by Woodyatt to the energizing of the intestinal muscle by the tonic action of the glucose. The mortality rate for the first 100 prostatectomies by the method described above was 3 per cent. The average postoperative stay in the hospital was twenty-two and five-tenth days.

Evacuation of Abscess.—*Prostatotomy* for relief of suppuration can be accomplished in several different ways, each of which has its uses under particular conditions. Sacral anesthesia, administered as previously directed (page 443), is the most satisfactory means of rendering any of these procedures painless and is recommended for all cases when the means of applying it can be commanded.

Choice of Route.—In considering the best method of approach to a prostatic abscess we should take account of the fact that when no treatment is given, these pus collections usually open spontaneously into both the rectum and the urethra. Those which empty their entire contents into the urethra are likely to be of the follicular type, or at least not very deeply seated in the parenchyma. Of the 104 cases considered by McCarthy[28] 74 opened spontaneously into the deep urethra. It would seem a reasonable procedure to open an abscess in the direction in which it was "pointing," but as there are certain very serious objections to rectal evacuation it is generally considered wise to avoid incision in that region, if it is in any way possible.

Perineal drainage may be undertaken by making an external incision at the mid-line, either straight or curved, and a longitudinal one beneath it into the bulbous urethra, through which the finger is passed to the abscess to assist in the evacuation of the pus. If the area of suppuration consists of several pockets it may be necessary to break down the septa between them, after which all the cavities should be thoroughly irrigated and drainage established.

The "curved prerectal transverse incision of Zuckerkandl," which exposes the posterior surface of the prostate and displaces the rectum backward, is the only one recommended by Thompson-Walker for perineal section.

Extraurethrally when the posterior lobe of the prostate is the seat of the abscess, it may be reached by what is known as Kocher's incision. A sound is inserted in the urethra, by means of which it is possible to ascertain the exact location of the bulb. Through a reversed-V incision, the intervening tissues are carefully dissected apart until the suppurating prostate is exposed to view. It is then possible to see in what direction the abscess is pointing, and to incise and evacuate it, or if the tissues are badly damaged, to do a partial prostatectomy.

The *suprapubic route* through the bladder is occasionally employed, but our own experience with this has not been particularly encouraging, and on general principles any breach of the abdominal wall is to be avoided if a less extensive procedure can be made to serve the surgeon's purpose and meet the needs of the patient's condition.

Protracted convalescence is the chief drawback to any form of open operation. This is especailly true when dealing with patients of the dispensary type. As most of these abscesses are sequelæ of gonococcal infection, the same need for "hurry-up methods" in treating them usually exists, as is the case with the great majority of gonorrheal patients.

Drainage by the rectum is never to be recommended and spontaneous evacuation through the rectal wall can only be regarded as a surgical calamity. The establishment of a recto-urethral fistula is almost certain to follow, and this may frequently prove highly intractable to treatment, if indeed it is not found altogether impossible to make it close.

Aspiration through the perineum by Barringer's technic, has much to recommend it.[4] The originator employs local anesthesia, injecting $\frac{1}{5}$ of 1 per cent novocaine and epinephrine through a $3\frac{1}{2}$ inch, 18 gauge needle, thereafter attaching a syringe to the same needle, so that aspiration may be carried out without withdrawing it.

Technic.—With the gloved index finger of the left hand in the rectum, the needle is entered between the urethra and the rectum, until its point can be palpated by the rectal finger, just in front of the prostate. From this point the needle is thrust forward into the lobe of the prostate where the abscess is thought to be. If any pus is found it is aspirated, the needle being pushed gently back and forward and the point rotated, so that all of the pus may be drawn out of the abscess cavity. Each lobe which gives evidence of harboring pus is punctured in turn, the needle being constantly guided by the finger within the rectum.

Limitations of Procedure.—The method should be restricted to gonococcal infections, for experience has shown that suppurations caused by the streptococcus, staphylococcus or colon bacillus are not suited

to aspiration. If the abscess has already broken through the capsule, and is pointing into the ischio-rectal fossa, or if it has extended toward the seminal vesicles, the case should be deemed suitable only for open operation.

Intraurethral Sound Method.[44]—A method of emptying a prostatic abscess which has proved very effectual in our practice is performed under sacral anesthesia with the patient in the lithotomy position. A somewhat pointed sound with a small curve, size 23-French, is introduced into the urethra, the progress and position of its tip being governed by a finger in the rectum. When the tip of the sound has reached the apex of the prostate, it is introduced about 2 cm. further, turned 90 degrees and then carefully forced through the lateral wall of the urethra into the corresponding lateral lobe of the prostate. The sound is then withdrawn as far as the apex, and in the same manner thrust into the other lateral lobe. If the incision thus made does not seem adequate for drainage, it may be enlarged by the introduction of a sound of greater caliber, 28-French, into the incision. Slight pressure will now usually produce an abundant flow of pus at the external urethral meatus, and by the injection of some simple irrigating fluid, the evacuations may be washed back into the bladder. The bladder should then be thoroughly irrigated through a large rubber catheter. No catheter need be left in the urethra.

The Treatment of Prostatic Stone.—As has already been noted (page 434) multiple small calculi may be found in the prostate (either at operation or during radiographic examination for some other condition) which produce no symptoms, and are better left alone by the surgeon. But more often, the presence of such stones will cause more or less distressing subjective symptoms, and where no prostatectomy is contemplated, it is essential that they be removed. Sometimes such concretions can be discovered and taken out through the cystoscope, and in certain cases careful irrigation and massage will force them into the urethra, but usually more radical means will have to be adopted.

Prostatotomy.—Prostatotomy through the perineum is the procedure frequently employed, the stones being scraped out and the infected area thoroughly drained.[22] Another method is to enter by the transvesical route which is thought to be less likely to traumatize the bladder sphincters and offer better access in case the gland is found so diseased that partial prostatectomy is later deemed necessary. Our own choice, when the patient is a young man not suffering from adenomatous hypertrophy, is to employ the perineal exposure of the prostate practiced by Young. By painstaking effort the calculi may be removed through the lateral slit, and most of the acini left in their normal positions.

Instruments for Prostatic Diagnosis.—The differentiation between benign hypertrophy and malignancy of the prostate is often a difficult matter, and the danger of biopsy under such conditions is so great as to cause most surgeons to hesitate to undertake it. Recently,

however, diagnostic "needles" have been designed and put on the market which make possible the withdrawal of a small section of tissue for microscopic examination under conditions which render dissemination of the cancer cells extremely unlikely. The use of such instruments is strongly advised whenever the necessity of obtaining a diagnostic specimen is imperative.[32]

FIG. 136.—Drainage of the prostate after removal of calculi, is accomplished by use of a cigarette drain, extending from the point of incision out between the layers of the levator ani muscle.

Surgical Treatment of Carcinoma of the Prostate.—Prostatic carcinoma is now recognized as a far commoner disease than was previously supposed. Improvements in technic have led to the removal of greater numbers of hypertrophied prostates, and the examination of excised specimens has in a good proportion of cases showed malignancy. Deaver reports 7.42 per cent of his cases malignant, while Young gives the frequency as 1 case of malignancy to 5 of benign hypertrophy. It therefore, becomes important for the surgeon to use great skill and care in establishing the differential diagnosis, for upon prompt early treatment of the malignant condition, rests the patient's only hope of relief.

Young's Procedure.—Young's procedure, usually with modifications according to the preferred practice of the individual surgeon, is the operation most commonly used for the enucleation of prostatic malignancy. With the patient in the exaggerated lithotomy position, antisepsis of the penis is obtained by an injection of argyrol 5 per cent, and a No. 24 sound passed into the anterior urethra as far up as the lower section of the prostatic portion. After antiseptic precautions, an inverted-V incision is made in the perineum, somewhat longer than that used in the procedure for the removal of benign hypertrophy. A space on each side of the central tendon between the tranversus

perinei muscle, the levator ani, and the ischio-pubic ramus externally having been opened up by blunt dissection, a bifid tractor is introduced, and after division of the central tendon, and the recto-urethralis muscle close to the bulb, the membranous urethra is exposed, incised longitudinally on the sound and the edges of the mucous membrane picked up with non-crushing clamps. At this point the prostatic tractor is introduced, after which the posterior layer of Denonvillier's fascia is divided on each side of the apex, thus exposing the anterior layer of the fascia. It will be recalled that it is this fascia of Denonvillier which throws a barrier in the way of progression of malignancy which has its origin in the prostate, backward to the rectum and its neighboring structures.

When the two layers of the fascia have been divided, the posterior surfaces of both prostate and seminal vesicles are freed and the prostate's sides exposed by blunt dissection. Especial care must be taken to avoid injury to the antero-lateral fascia, to keep well within it and see that it is separated from the prostate, as failure to observe this precaution will result in incontinence, which, from the patient's point of view at least, will largely nullify any good results obtained by the operation. It should be borne in mind that directly in front of this fascia lie the nerves and bloodvessels which supply the external sphincter and the triangular ligament, and to avoid any injury to them, it should be stripped up from the prostate with the greatest care.

The membraneous urethra is now divided directly in front of the tractor which has been already introduced, and the prostate, freed laterally, posteriorly and anteriorly beneath the antero-lateral fascia, can now be drawn outward. The bladder is thus brought toward the operator, so that it can be incised and its exterior exposed. A curved incision is made across the trigone, passing about 1 cm. below the urethral openings on either side, and so directed as to include mucosa, submucosa and muscle tissue. The bladder being pushed upward, the tissues covering the anterior surfaces of the seminal vesicles and vasa deferentia come into view, and are freed *en masse*, the fascia containing the blood supply at the upper end of the seminal vesicles on each side, being ligated as far above the prostate as possible. Each vas deferens is dissected free in turn, clamped and divided, this final maneuver leaving the entire malignant mass so liberated that it can be removed in one piece, which contains the entire gland with its capsule, the prostatic urethra and a small section of the membranous portion as well, a section of the bladder which includes the greater part of the trigone, both the seminal vesicles and some 6 or 7 cm. of the vas deferens of each side.

The bladder is then drawn down and anastomosed to the remaining portion of the urethra over a small retained catheter held in position by a strip of adhesive plaster fastened to the penis, the remainder of the bladder incision being closed with a continuous chromic catgut suture. Avoidance of the antero-lateral prostatic fascia not alone

does away with the incontinence that is so likely to be the sequel to such a procedure, but it also makes hemorrhage very much less, so that with care in clamping and ligating all the bleeding points about the seminal vesicles, one can carry out the whole operation with very little bleeding.

Radium Treatment of Prostatic Malignancy.—One of the chief applications of radium in urology has been to cancer of the prostate. Under certain conditions the prospects of success in combating the disease which are offered by radium therapy are considerably brighter than those held out by surgery. And even where the disease has advanced beyond all hope of cure by any means, radium can often be so applied as to lessen the distress and discomfort, and render the patient's last days more endurable both for himself and those who are employed in caring for him.

Contraindications.—Before applying radium treatment there should be a thorough roentgen-raying of the entire body to make sure that no metastasis has already taken place. If secondary deposits of malignant cells are found in the chest or lumbo-sacral region it should immediately be recognized that radium treatment can offer nothing more than palliation. Defective renal function is another contraindication, for the added strain which the elimination of the epithelial débris which is cast off from the tumor after exposure to radioactivity puts an added strain upon the kidneys, and if their function is already defective, as is frequently the case when prostatic hypertrophy has induced long-continued retention, this increased demand upon them might easily prove fatal.

Various methods of applying radium are now in use, and indeed, the very multiplicity of the procedures advised indicates that the perfect method has yet to be found. The earliest attempts at treating prostatic malignancy with radium consisted simply in placing a tube of radium salts, screened usually with silver, in a urethral catheter which was introduced in such a way as to bring the radium container in direct contact with the malignant prostatic tissue.[14] Somewhat later this method was made more exact by employing a cystoscope so that the radium could be placed under direct vision and the gradual improvement of the instruments soon made it possible to adjust the applicator entirely by manipulation, using both the urethral and rectal route, and by passing the tube or other radium container into the bladder, to bring about "cross-firing" from three different directions.[58] The dosage used successfully by Young was 100 mg. of radium applied for an hour in various locations which could be reached through the rectum, bladder or urethra.

At the Mayo Clinic[7] a No. 10 soft-rubber rectal bougie marked off in centimeters with a window cut in the side to hold the radium tubes is used for work about the prostate. When the bougie is first inserted it is so placed as to bring the window within the bladder area of the rectal mucosa. After an hour of exposure the bougie is withdrawn

the distance of 1 cm., thus exposing a new area of rectal mucosa to the effects of the rays given off from the contained radium. For urethral applications a brass tube covered with rubber is used for the radium container, which is adapted to the curves of the urethra by an attached handle of rubber which is very flexible. This applicator is withdrawn at regular intervals in the same way as the rectal applicator. In the earlier work at this clinic as much as 1482 mg. hours was applied in the rectum, and 217 mg. hours in the urethra. It was later decided, however, that this was too high a dosage, as prostatitis frequently resulted, and at present this form of radium treatment is little used.

The method employed by Barringer of the Memorial Hospital, New York[3] consists of inserting through a urethroscope small tubes of radium element to which linen threads are attached to facilitate their withdrawal. These tubes are about 2 cm. in length and are screened with 1 mm. of rubber and 0.6 mm of silver. The urethroscope is removed when the tubes are wholly within the bladder. This method has been found especially useful in cases where the malignancy of the prostate has invaded the urethra. Two hundred millicurie hours was the largest dosage employed.

Radium Needles.—The "needle method" lately introduced by Barringer has largely replaced the older ways of applying radium to the malignant prostate. The usual needle is of steel averaging from 10 to 15 cm. in length, the last 3 cm. serving as the container for the radium. At first large dosage of radium element was used, as much as 12.5 mg. being inserted and allowed to remain in one spot for one-half or even a full day. Experience showed that as much was accomplished by leaving the needle in place only four or five hours, and that the resulting necrosis was not so great, thus placing less burden upon the already weakened kidneys. By using several needles inserted at different angles and withdrawing them five or six times in twenty-four hours, all the prostatic tissue could be thoroughly irradiated without over-exposing any one spot. Another method of needle application is to insert two needles, each containing $12\frac{1}{2}$ mg. of radium element, passing them through the perineum under local anesthesia, their progress being guided by the operator's finger in the rectum. This can be used in conjunction with applicators in the rectum, urethra and bladder, and serves to irradiate those areas of tissue which the rays from the other applicators cannot reach. Hourly treatments of 100 mg. of radium each are used, applications being made 20 times through the rectum, 10 times through the urethra and 10 times through the trigone, with the additional irradiation from 8 needle applications of $12\frac{1}{2}$ mg. inserted through the perineum.

Radium Emanation "Seeds."—The latest method, and one that bids fair to displace all the others because of its ease of application and relatively low cost, is the use of radium emanation "seeds." As already been indicated, one of the greatest drawbacks to the use of radium therapy for carcinoma of the prostate is the strain upon the

kidneys induced by the necessity of eliminating the products of necrosis. Usually about each radium container after exposure for any length of time necrosis of the tissue for a zone of approximately 1 cm. will take place. But by making use of extremely minute capillary tubes of radium emanation, each containing not more than 1 millicurie, and often as little as 0.6 millicurie, this necrotic area can be reduced, while by implanting a sufficient number of the "seeds" the same amount of millicurie hours of exposure can be obtained, although the systemic reaction which they produce will be materially lessened. Various methods of accomplishing the seed implantation have been recently described.[33,53] That employed at the New York State Institute for the Study of Malignant Diseases is as follows:

The patient is placed in the lithotomy position, the perineal region shaved, and the skin cleaned with iodine. The skin and tissues immediately subjacent are first infiltrated with novocaine, and a few minutes later by employing a needle about 4½ inches in length, the tissue in front of the prostate and the gland itself are likewise injected with the anesthetizing agent. With the gloved finger in the rectum as a guide, a medium-sized trocar is inserted at about the mid-line of the perineum up as far as the prostate. An instrument with a sharp cutting edge upon the obturator has been found most desirable. After the trocar has been inserted the desired depth the obturator is withdrawn and through the hollow trocar needles are inserted, each carrying at its point a capillary tube or "seed" of radium emanation, which is deposited in the substance of the prostate gland. The needles are directed to different portions of the gland simply by changing the axis of the trocar anteriorly, posteriorly or laterally, and thus from 15 to 20 seeds can be easily placed in a short time. The strength of the radium emanation contained in each seed varies from 0.6 to 1 millicurie, and it is aimed to place them about 1 mm. apart in the tissue to be irradiated. In the early cases the ease of approach to the posterior lobe makes this procedure particularly satisfactory. In certain cases where the seminal vesicles are involved with the prostate gland in the indurated mass, these structures also may be "seeded" by passing the needles through the gland and depositing the "seeds" of emanation within the substance of the indurated vesicles. After a careful cystoscopy and the charting of the intravesical changes, *i. e.*, enlargement of the middle and lateral lobes, elevation and infiltration of the lower portion of the trigone, or the rounding and fixation of the anterior commissure, these portions may readily be "seeded" as occasion demands without removing the trocar. In addition to the radium treatment the periprostatic structures and the surrounding structures also receive deep roentgen-ray therapy, in from 80 to 100 per cent of the erythema dose.

Improvements in the "seeding" method have been lately introduced by the use of a needle provided with a "loading slot,"[31] which has greatly facilitated the accurate placing of the capillary tubes. Heretofore

the exact distribution of the "seeds" and the amount of dosage has been largely a matter of guess work, as the necessity of using a separate needle for each tube made it necessary to constantly withdraw the needles, with consequent interruption to vision and great delay in placing a sufficient number of tubes to secure proper irradiation of any considerable amount of tissue. A cystoscope is used with this needle and it can be carried into the prostatic urethra and its point embedded in the prostate at any desired angle, all under direct vision. The "seeds" are not gummed to the needle point with vaseline but are placed in a loading slot in the proximal end of the instrument, and when the needle point has been driven in to the greatest depth which it is desired to irradiate, the capillary tube is pushed out by an obturator and buried in the designated point in the tissue. The obturator is withdrawn behind the loading slot, and the needle point drawn backward the distance of 1 cm.; a second "seed" is discharged without altering the course of the needle, so that it is implanted exactly 1 cm. behind the first "seed." This process is repeated until as many as five or six "seeds" have been laid in a straight line 1 cm. apart, and the needle is then withdrawn so as to make a new channel in which a second line of "seeds" is implanted in the same manner. The whole area of malignant tissue can thus be quickly and accurately exposed to radiation, at no time being out of range of the operator's vision, and the implanter being always within the cystoscope, there being no necessity of withdrawing it at any time.

Filtered and Removable "Seeds."—The latest improvement in the "seeding" method of radium application consists in screenage of the bare tubes and provision for their removal when the desired amount of radiation has been given. Workers at the Memorial Hospital (New York) have made use of gold-filtered radon (radium emanation) applicators of practically the same size as the bare tubes previously employed, which they implant in the same way by burying them directly in the neoplastic tissue. A still greater improvement is the Muir removable platinum radon "seed," which makes use of platinum instead of gold filtration, and has the very desirable feature of being capable of withdrawal by means of an attached thread which is perfectly controlled at the time of implantation[31] so as to be available whenever it is desired to conclude the treatment. With platinum filtration it is possible to use as high a dosage as $2\frac{1}{2}$ millicuries in each "seed," for the screenage eliminates practically all caustic radiation, and a sphere of tissue with a 1 cm. radius in all directions from the implanted "seed" will be thoroughly radiated without producing the slightest necrosis. The possibility of removing the applicator, so that it does not remain as a foreign body in the tissue, makes these new "seeds" of especial value to the urologist, and their general employment will undoubtly extend the indications for radium therapy in urologic work far beyond anything heretofore thought possible.

Availability of Radium Therapy.—These improved methods of "seeding" with radium emanation have placed this therapy within the reach of the general practitioner, for it is now possible to obtain the "seeds" and full directions for their application so that treatment may be carried out at considerable distance from the large centers which were until very recently the only places where a patient suffering from cancer of the prostate could hope to find relief by this means. Compared to the extremely high cost of radium element, the emanation is relatively inexpensive, and can safely be shipped for considerable distances from the laboratory where it is generated and placed in the tubes. The use of radium emanation has several other advantages, for it has been calculated that the strength of the radiation procured through the use of the capillary tubes decays at a uniform rate, and that a tube placed at a given point will give off a steadily declining amount of radiation until it finally becomes altogether inert. In the words of the late H. H. Janeway: "The emanation introduced within the tissue in the manner described undergoes a continuous decay at a uniform rate, diminishing to one-half its value in three and eighty-five-hundreths days. As a consequence, after the lapse of a certain period, the embedded tubes become inert and are either encysted or sloughed out, according to the character of the tissue around them. The total dosage administered from a tube containing any quantity of radium emanation may be expressed by multiplying the contained quantity of emanation by 132; thus, if a tube contains 2 mc. the dose delivered by it may be expressed as 264 mc. hours. This method of expressing dosage of buried emanation is useful only for comparative purposes. It does not mean that the activity of the tube ceases after one hundred and thirty-two hours but merely that the total dosage may be compared to that delivered by a tube containing 2 mg. of radium element for one hundred and thirty-two hours; but only compared to this dose, because the radium element for the same length of time undergoes no diminution in quantity and therefore, its intensity is constant. The emanation, however, becomes continuously less, and in consequence, more especially during the latter period of the delivery of its total number of millicurie hours, falls off progressively in intensity."[20]

It is possible, in view of the known radiative powers of the number of tubes implanted and the comparatively small value of the emanation which they contain, to permit a patient to depart after the implantation operation is completed, and though it is always desirable to place these prostatic cases in a hospital, this possibility of escaping the prolonged hospital stay will often induce him to undertake the radium treatment when other forms of therapy would be refused.

Treatment of Prostatic Tuberculosis.—In a thorough study of the literature relating to tuberculosis of the prostate, Crowder[9] found that spontaneous healing occasionally occurs. Small caseous areas may suppurate and discharge through the urethra, later healing by cicatrization; they may become encapsulated and latent, or they may undergo cal-

cification and encapsulation. Von Frisch states that he has seen two cases recover even after the bladder had become involved. Even when fistula formation and extensive complications are present, if no extension to the kidney has occurred, healing may take place spontaneously or as the result of operative intervention. Rectal fistulæ and especially recto-vesicular fistulæ, are likely to give rise to septic infection. They are not, however, to be looked upon as hopeless. Albarran[1] also takes a rather optimistic view of the outcome of this infection. He advises curetting existing abscesses, to be followed in some cases by prostatectomy, though just what he regards as an indication for excision of the gland he does not make clear. If the tubercular focus is well encapsulated and is evidently an extension from a primary lesion elsewhere in the genito-urinary tract, he does not advocate any kind of interference, believing that treatment should be directed wholly to the site of origin.

Surgical treatment is applicable only to relatively few cases. If no signs of infection can be detected in the lungs or elsewhere outside the genito-urinary tract, and the patient's general condition is good enough to warrant it, the procedures elsewhere described (page 446) for the extirpation of uro-genital tuberculosis are applicable. Our opinion coincides with that of Crowder who thinks that the logic of surgery would seem to lead to the conclusion of operation when the disease is sufficiently limited and seems to offer a fair prospect of radical removal. Recent improvements in the technic of prostatic surgery and its brilliant results also argue to this end. Although operation as a rule has been undertaken relatively late in the disease, after the development of abscess and fistula, the results have been generally excellent. Cures have not been obtained in all cases, although a fair proportion have had that fortunate outcome, and those succumbing ultimately in the infection have nearly always received a great measure of relief from distressing subjective symptoms. If operation is to be ultimately necessary to afford such relief, it would better be undertaken while the patient's strength lends him a good degree of recuperative power and offers hope of cure.

Incision.—The incision when it is purposed merely to evacuate a tuberculous abscess, had best be a tranverse perineal one, which gives a good exposure of the infected gland, and is the most convenient place for handling a fistula, should one persist. If it is intended to extirpate the entire gland, the technic recommended for prostatic hypertrophy or the removal of a carcinomatous prostate should be carried out.

Local Treatment.—Various forms of local treatment have been recommended from time to time but in general, they can hardly be considered as more than palliative. Lydston[27] averred that the method of hypodermic medication by iodine and chloride of gold in the form of Clark's solution, offered hope of benefit or even cure. He also recommended nucleins and tuberculin. The local treatment should

consist first of irrigation of the bladder and prostate with warm solution of boric acid, followed by the instillation of iodoform and ether emulsion. Iodoform in the form of rectal suppositories has seemed beneficial. Instillations of silver nitrate and other irritant drugs he regards as seldom beneficial and usually actively injurious. Where possible it is better to use a short urethral nozzle for irrigating bladder and prostate, as longer instruments are likely to induce mechanical irritation of the prostate. Abscesses should be evacuated, scraped and packed with iodoform gauze, and all sinuses thoroughly curetted and treated with iodoform. This author also regards interstitial injection of iodoform emulsion into the affected gland as a logical method of treatment.

Prostatic Massage.—We have already made a number of references to massage of the prostate. This has been practiced to a considerable extent for a number of years, the technic, as well as the results obtained varying widely in the hands of different operators. Some merely stroke and rub the perineum, while others place the thumb upon the gland as palpated through the perineum, and the index finger upon its rectal aspect, thus being able to knead the gland between the two digits. A favorite method is to place the patient in the Sims' position or standing with the body bent forward as over the back of a chair, or again upon his knees and elbows, while the operator with his gloved index finger in the rectum exerts gentle pressure alternately upon the lobes palpable from that position, using a downward stroking motion toward the point where the prostatic ducts open upon the urethra. Secretions may later be expressed from the ends of the ejaculatory ducts and from the sinus pocularis by bringing the firmly pressing finger downward along the posterior urethra. The vigor with which this procedure can be carried out must be regulated by the operator's judgment, but in general, vigorous massage should never be given oftener than two or three minutes once a week. Gentle massage may be carried out for the same length of time at somewhat more frequent intervals, twice or even three times a week if it is deemed desirable. The bimanual method, the other hand exerting counter-pressure above the symphysis, is considered more effectual by some operators, especially where it is desired to strip the seminal vesicles as well.

Some authorities, notably Chetwood, employ instruments of hard rubber or metal, by which the more inaccessible parts of the prostate, and of the adjacent seminal vesicles can be reached. In certain cases these contrivances are useful, but in general, the benefit to be derived from prostatic massage is in direct proportion to the acuteness of the operator's sense of touch, and as this is greatly lessened when instruments are used, their employment is likely to do more harm than good.

Prostatic massage is said by Farman[15] to be most beneficial in three types of cases which he enumerates as follows: Simple catarrhal prostatitis, chronic parenchymatous prostatitis and atonic or atrophic conditions of the prostate and seminal vesicles. Simple catarrhal

prostatitis is a common accompaniment of the first attack of gonorrheal urethritis in a young man, which often displays no more acute symptoms than a persistent muco-purulent discharge at the meatus, with perhaps increased frequency of urination. If the engorged prostate is emptied by massage, in conjunction with proper treatment of the urethral condition, recovery is usually rapid.

For chronic parenchymatous prostatitis, massage of the prostate, systematically and thoroughly carried out, will prove very helpful as a supplement to the approved method of handling the infection in contiguous organs, which differs considerably in the practice of various urologists.

By atonic or atrophic conditions are meant those which induce premature ejaculation or complete impotence, prostatorrhea or spermatorrhea. In certain of these cases, prostatic massage may prove of considerable benefit depending on the age of the patient, his general state of health, and the primary etiological factor, being less effectual in long-standing cases due to venereal infection, or alcoholic and sexual excesses.

Acute congestion such as occurs frequently in benign hypertrophy of the prostate, is often greatly relieved by carefully applied massage, but in acute primary or recurring inflammatory conditions of the genito-urinary tract, it is best to omit it. Acute epididymitis which follows too vigorous or too early prostatic massage, is a distressing complication for which the operator is frequently blamed by the patient.

Focal Infection.—Focal infection emanating from the prostate has not received the consideration to which it is entitled, but the connection between this organ as an infective focus, and systemic disturbance has been repeatedly demonstrated. It has been remarked by Pelouze[35] that in many patients suffering from toxic absorption from a focus of infection in the prostate, there occurs a great increase of symptoms within twelve hours following prostatic massage, and the fact that this reaction is in most cases followed by marked relief of these and previous symptoms, shows the value of prostatic massage in this connection.

Caution must, however, be observed at all times. In earlier communications elsewhere cited (Ref. No. 50, Chapter XI) this same writer has warned us that there is evidence that persistent prostatic massage has a decided tendency to light up tuberculous foci in other parts of the body, particularly in the lungs and in the epididymis. Commenting upon this statement, Farman has said, The lymphatics of the prostate act as a natural defense against infection. Such a barrier may be broken down by manipulation at the improper moment, permitting the escape of infectious material into the seminal sacs, vasa deferentia, epididymis tubules, and even into the general circulation. It is to be avoided in marked neurotic or asthenic states.

Subsequent epididymitis may be averted, according to Lockhart,[25] by practicing massage of the prostate only at the proper time, and after the expressed contents of the gland has been voided by the patient,

filling the bladder with a 1 to 8000 solution of potassium permanganate, which is to be immediately voided. In lieu of this, a 2 to 4 per cent protargol or other organic silver solution, may be instilled through a catheter and retained until the next urination. A further precaution consists in administering atropine, either by suppositories ($\frac{1}{75}$ gr.) or hypodermically ($\frac{1}{100}$ gr.) for one or two doses prior to giving the massage.

Roentgen-ray Therapy.—Frequently the application of roentgen-ray to a hypertrophied prostate which is producing pressure symptoms and other characteristic manifestations, will greatly improve the local condition and not infrequently has altogether averted the necessity of surgical intervention. It has been recently said that[43] whether there is a real diminution of the size of the gland, or only a subsidence of the chronic inflammation is difficult to determine, and perhaps the true explanation is to be found in the fact that with advancing years a certain amount of prostatic enlargement is physiological, so it is only when the gland becomes inflamed that any symptoms referable to the prostate are in evidence; therefore, reduction of the inflammation would cause the symptoms to subside, although actually the size of the gland would not be materially affected.

Technic.—The best results have followed the employment of the rectal route, making the application of the rays directly to prostate and perineum. The patient is placed in the genu-pectoral position and the applicator inserted. This applicator is usually a tube of lead glass, covered with rubber to prevent injury to the rectal mucosa. It is so arranged that the rays strike directly upon the prostate gland, and at each treatment a different area is selected for radiation. Treatment should be given in a series of four weekly applications; then rest for one month, after which a second series of four weekly treatments is given. If improvement is marked two months rest should now ensue, to be followed by a third similar series; but unless the improvement in the condition of the gland is decidedly noticeable by this time, no further applications are likely to be of benefit. In most cases, however, there will be decided benefit even from the first series, and occasional prophylactic applications should be made at extended intervals thereafter, in order to keep the symptoms in abeyance.

Electrotherapy.—Electrotherapy has been combined with roentgen-ray with very beneficial results. Wyatt[56] suggests that in the presence of chronic inflammatory changes due to prostatic hypertrophy, diathermia should be applied to the gland either direct or indirect, dose from 500 to 900 milliampères, time from ten to thirty minutes. The prostatic electrode is placed in the rectum against the prostate, the other over the pubis. This is followed by an ionizing dose of roentgen-ray, and massage by the Morse *sine wave*, or slow sinusoidal, to squeeze out the débris from the prostate and establish better circulation in this organ. The second electrode in this instance, is placed over the lumbo-sacral region. He also advocates the ultra-violet

ray, both local and general, for its antispetic and general systemic tonic effects.

Deep Roentgen-ray Therapy in Prostatic Carcinoma.—Deep roentgen-ray therapy in prostatic carcinoma has been used with satisfaction in a number of instances. The radiation from roentgen-ray tubes by using high voltage and heavy filters is very similar in character to the radiation produced by radium, the only difference being that the wave length of the gamma ray of radium is somewhat shorter than that yet produced by the roentgen-ray. This may be combined with radium treatment. In using roentgen-ray under such circumstances, an attempt is made to give a full erythema dose to the full depth of the prostate. Voltage of 200,000 or more is used with 1 mm. copper filter and 50 cm. skin distance.[41]

Ultra-violet Ray or Quartz-light Therapy.—Use of the ultra-violet ray or quartz-light therapy has proved of great benefit to certain peculiarly obstinate cases of chronic prostatitis, and other diseased conditions of the gland. Ultra-violet ray therapy is called a powerful and prompt remedy for clearing up obstinate prostatic cases before the period of sclerotic enlargement changes has set in.[29] The patient stands with the body bent at right angles. The prostatic applicator, moistened with soap suds is gently inserted into the rectum with an upward tilt until the resistance of the gland is encountered. The patient will usually complain of subjective discomfort and a desire to urinate. The first dose is of three minutes on the first rheostat button. Usually the reaction of tenderness and congestion subsides in a day or two. The dosage is repeated at intervals of three to five days, being gradually increased up to fifteen minutes and second speed rheostat buttons. The tenderness and "bogginess" should gradually subside. The rectum must, of course, be free from fecal material, otherwise no actinic light can reach the tissues toward which it is directed. The marked stimulation of the rectal mucosa usually produces a slight show of blood at the next defecation. The patient should be warned of this, and it should be explained to him that it does no harm. But if the blood persists and much is in evidence, it will be best to stop treatment until all signs of it have disappeared.

Vaccines.—Vaccines have proved very useful in the authors' practice in certain cases of arthritis where the infective focus was located in the prostate, but in other patients there was no appreciable effect. Many of the suggestions offered for the handling of acute and chronic gonorrheal urethritis, find application in the treatment of prostatitis, both acute and chronic, and in general, the rules for diet, restriction of sexual activity and personal hygiene laid down for urethritis, are equally serviceable in this connection.

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CHAPTER XII.

THE BLADDER.

EMBRYOLOGY OF THE BLADDER.

Elsewhere we have described (page 303) the formation of the vesico-urethral anlage by separation of the primitive uro-genital sinus from the rectum, followed by differentiation into anlagen of bladder and urethra. During this process of separation gradual changes occur in the proximal ends of the mesonephric ducts and ureters, the terminations of the ducts becoming dilated and then gradually absorbed until the ends of the ureters are provided with separate openings, these orifices lying laterally above those of the ducts. The point at which these two sets of ducts open marks the boundary between a slightly larger cephalic section of the sinus, the anlage of the bladder, and a smaller caudal part, which becomes the urethra and uro-genital sinus.[3] In embryos no longer than 7 mm., the proximal ends of the mesonephric ducts are funnel-shaped, but when a length of 10 mm. has been attained, the growth of the bladder brings about the acquirement of separate openings already described. The lateral walls of the bladder grow more rapidly than its dorso-median urethral wall; so that the ureters are carried cranially and laterally upon the wall of the bladder, while the mesonephric ducts open close together on a hillock, Müller's tubercle, into the dorsal wall of the urethra. We perceive thus that there is an area of mesodermal origin lying between the orifices of ureters and those of the mesonephric ducts, which when they have reached a state of complete development we term the ejaculatory ducts.

According to Arey, the transitional vesical epithelium appears during the tenth week of fetal life, but the circular and longitudinal muscle layers are developed at the end of the second month. In most specimens older than ten weeks the longitudinal muscle layer is in evidence, but it is not until the third month that the sphincter vesicæ is matured.[1]

Entrance of the Ureters.—It was observed by Wesson[70] that a transverse section of the bladder of an embryo 21 mm. in length presented an appearance similar to a half-moon, and although occasionally the ureters entered at the tops of this crescent in accordance with the usual embryological descriptions, more often they pierced the wall on the dorsal aspect about 0.03 mm. from the tips. At 80 mm. fetal length the ureters take an oblique course as they enter the bladder. This same observer noted that in a 21 mm. embryo the bladder portion has enlarged until it is twice the diameter of the urethra and has

assumed a cone-shape, while in slightly larger specimens a definite enlargement above Müller's tubercle can be made out, so that the structures have much the same appearance as in the fully developed bladder and urethra.

Dimensions of the Fetal Bladder. -In a fetus of 5 cm. crown-rump length, about the age of ten weeks, the bladder at the trigonal region has about the same circumference as over the entire remainder of its area, being at this stage a tubular structure which narrows down gradually as it approaches its orifice, so that at no point is there a portion defined with sufficient clearness to permit indication of the location of what is later to become the vesical orifice.

The walls of the bladder are everywhere uniform in thickness except in the region of the trigone, at which point the wall is nearly double the thickness found in any other portion. The connective tissue strands can be traced from the ureters out into the trigone, the trigone itself being quite definitely superimposed upon the vesical wall. The increased thickness of the base of the bladder wall extends throughout the trigonal region, but is most marked at the beginning or interureteral area.

When the fetus is some 7.5 cm. in length, which is about the age of thirteen weeks, a considerable change will be noted in the bladder. At this stage the entire base area will be found to be thicker than any other portion of its circumference, this thickening being more marked the nearer the trigonal region is approached.

Musculature.—The musculature of the embryonal bladder can now be distinctly recognized as a deeply staining tissue composed of circular interlacing and longitudinal strands, which are easily differentiated from the connective tissue elements forming the major portion of the bladder wall. The strands of muscular tissue are much larger and more abundant at the base or inferior portion than at any other. In the region just superior to the trigone, where the *bas-fond* will later develop, the inferior wall is three times as thick as it is at any other part of the circumference. Throughout the entire vesical length on the lower aspect of its inner surface the lining mucosa lies in folds, though everywhere else it is smooth.

Trigonum Vesicæ.—The trigonum vesicæ is about five times as thick as the remaining portion of the vesical wall. The muscular strands of which it is composed are much finer in texture than those found elsewhere, and many of them may be traced between the two ureters and so out into other portions of the trigone. Wesson's observations showed that no rules can be deduced as to the shape and size of the trigone, as different specimens which he examined showed great individual variations, independent of age, sex or size of the bladder. He describes it as a smooth triangular area lying at the base of the bladder, having the two ureters and the vesical orifice at its angles. In the trigonal region we find the two muscle layers of the bladder wall, the external longitudinal and the internal circular, upon which is

superimposed the submucous or trigonal muscle, this being actually an expansion of the longitudinal muscle layer of the ureters and their sheaths which extend downward and pass into the urethra. Thus the trigonal muscle is a definite entity arising from the longitudinal muscle fibers of the ureters, superimposed upon the muscles of the bladder wall. By the time the embryo has reached 21 mm. total length, the trigone forms an equilateral triangle, each side of which measures 0.36 mm.

The Bladder of New-born Infant.—The bladder of a new-born infant examined by one of the authors, showed a great increase over fetal dimensions in the size of the base, at the point where the ureters join the vesical wall and begin their oblique course through its lumen. This practical doubling in thickness was maintained throughout the trigonal region, being most pronounced between the ureters where the intra-ureteral ridge is made up of fibers extending from one ureteral wall until they intermingle with those of the opposite ureter. But just below this ridge the bladder walls become comparatively less thick, being but little larger than the rest of the wall. As the sphincter is approached the entire vesical wall increases greatly in size, the base however, always remaining relatively of greater dimensions than any other part, and the trigonal fibers being invariably distinguishable from the tissue of the vesical parietes proper. The mucosa over the trigone is much more richly supplied with bloodvessels than any other portion.

Internal Sphincter in the New-born.—The internal sphincter in the new-born is made up of circular fibers which are very numerous at its upper part. It is larger at the floor of the vesical cervix and while many of the fibers pass entirely around the orifice of the urethra, the majority of them mingle with the muscle bundles of the bladder on its ventral aspect which at this point approach much closer to the lumen of the urethral orifice than in the posterior wall. In its ventral portion a number of small longitudinally disposed fibers can be distinguished. The lower part of the sphincter ends considerably outward from the point where the tubules of the posterior lobe of the prostate have extended backward behind the two ejaculatory ducts.

Summary of the Embryonic Development of the Bladder.—The bladder of a fetus of ten weeks' development consists of a cylindrical tube composed of embryonic connective tissue. Near its base it is joined by the two ureters which pass through its wall, fibers from the ureters being superimposed upon the bladder wall to form the trigonum vesicæ. No tissue resembling muscle is present, and the future vesical sphincter's site can be distinguished only by the change in the size and shape of the lumen.

At the thirteenth week the muscular development has begun, and is observed as circular interlacing and longitudinal strands of tissue that take on a deeper pink color when stained than does the connective tissue which still forms the major portion of the bladder wall. The

entire base of the bladder is thicker than any other portion of its circumference, while the superimposed trigonum vesicæ and the wall under it are five times as thick as the anterior wall. The muscle fibers observed in the trigonum are traced between the two ureters and downward upon the remainder of the trigone. They are finer in texture than the muscle fibers in the bladder wall. The site of the internal sphincter is marked by a sudden narrowing in the size of the lumen, while a few circularly arranged muscular fibers are distinguishable.

By the sixteenth week there has been a very great change in the musculature of the bladder, the fibers being sufficiently developed to be sharply defined from the surrounding connective tissue, and it is easy to trace from the ureteral walls the muscle fibers forming the trigonum vesicæ. The mucosa, though arranged in folds everywhere else, is smooth where it is tightly attached to the trigone. The sphincter vesicæ is now quite sharply outlined by the many muscular fibers which encircle the constricted lumen of the vesical neck.

At the twentieth week the muscular fibers have become very much more prominent, but the most striking change is the enormous increase in the size and the number of the fibers forming the internal sphincter, which seem to be tightly closing the vesical orifice. The longitudinal fibers of the bladder intermingle with the outermost of the sphincter fibers. At this stage the mucosa of the trigonum vesicæ is smooth, although folded elsewhere.

In the twenty-second week fetus there is noted still greater extension in the size of the bladder musculature and a marked increase in the dimensions of the inter-ureteric bar. The trigone and the bladder wall under it do not show the great increase in size over the rest of the vesical wall observed in the younger specimens. The fibers forming the trigone are observed to be more tightly bound together than the fibers of the bladder wall, while over it the mucosa is smooth; the sphincter is large and closely united to the rest of the bladder musculature.

Further increase in the size of the muscles forming the vesical wall, trigonum and sphincter is noted at the thirtieth week of fetal life, as well as in the bladder of the new-born. At birth the sphincter seems to be larger than elsewhere at its upper margin, and is very thick on its posterior quadrant. Many of the fibers appearing there do not entirely encircle the orifice but intermingle with longitudinally arranged fibers from the anterior surface of the bladder. At the lower or outermost part of the sphincter there are fewer fibers, but they all encircle the orifice completely.

ANATOMY AND PHYSIOLOGY OF THE BLADDER.

The Normal Adult Bladder.—Location.—In the new-born infant, as we have seen, the base is the most prominent part of the bladder

and the sphincter fibers completely encircle the urethral orifice, which at this time of life is on a level with the upper edge of the symphysis pubis, so that the bladder is in infancy, an abdominal viscus. During the first two decades however, the bladder gradually stretches downward, the base descending lower and lower, until, when full adult development has been attained it has become practically a pelvic organ, for only when fully distended, does it rise into the abdomen. Its position in general is a little lower in females than in males, as the position of the prostate, and the greater length of the male urethra tend to retain it further up.

Supports.—The bladder is held in position by nine attachments, four of which originate in the vesical layer of the pelvic fascia, and are generally termed the *true ligaments*, in contradistinction to the other five attachments which consist merely of reflections of the peritoneum forming vesical connection with the walls of the abdomen and pelvis, and are designated as *false ligaments*.

An important consideration to the surgeon in regard to these peritoneal attachments is that the bladder is in part an extraperitoneal organ, for though its sides and posterior aspect are completely enveloped by this tissue, in front, that part of the vesical wall which lies behind the symphysis is not covered by peritoneum, its only envelope being the prevesical fat. The bladder base is also without peritoneal covering, thus making surgical intervention in this region comparatively easy and safe.

Structure of the Bladder Wall.—The outer or serous coat of the bladder is in this way left incomplete on its anterior surface; within this, however, is a more extensive coat of fibrous tissue, and below this lies the muscular coat, which consists of three layers. The fibers of these three muscular layers unite into rounded fasciculi, separated by connective tissue sheaths; those of the upper layer being longitudinal; the median layer consisting of circular fibers; while the innermost layer is composed of very delicate longitudinal fibers, loosely arranged within the submucosa.

The interior of the urinary reservoir is completely lined with mucous membrane which is continuous with the lining of the ureters above and of the urethra below. This is loosely attached to the muscular coat through the agency of the submucosal connective tissue, and when the bladder is empty lies in folds, save in the region of the trigone which always remains smooth. Many small racemose glands are scattered through this mucosal lining, especially about the urethral orifice, each gland being lined with columnar epithelium.

Muscles.—In the fully developed bladder the muscles are of two distinct functional types; those which act to contract the vesical neck and to retain the content until the proper amount for evacuation has accumulated—the sphincter muscles; and those concerned in contraction of the vesical wall and expulsion of the contents—the detrusor urinæ muscles. In any anatomical discussion of the bladder it must

be kept in mind that its size and position are never fixed and what is perfectly true and evident in the case of the full bladder is by no means applicable to the empty viscus. The bladder musculature and the mechanism by which the urine is collected and evacuated thus becomes of the greatest importance in any consideration, not only of the viscus itself, but of the anatomy and surgery of all adjacent structures.

The most muscular part of the bladder is the so-called neck, that is the urethral orifice with its surrounding ring of circular fibers. *The sphincter* consists entirely of smooth muscle fibers, normally in a continuous state of tonic contraction. Its function is to allow the accumulation of urine within the bladder, and to relax so as to permit its escape at the proper time only.

The *detrusor urinæ muscle* comprises all the remainder of the bladder musculature, and like the sphincter is made up entirely of the smooth involuntary fibers already described. The function of this main portion of the bladder musculature is to contract the wall upon the fluid content when sufficient has accumulated to raise intervesical pressure to the point where it induces the desire to void, that is, to expel this content through the relaxed urethral sphincter.

Innervation of the Bladder.—The innervation of the vesical muscles will thus be seen to be of great importance, and how great is the appreciation of this fact is shown by the large number of eminent physiologists, neurologists and urologists who have given this subject their attention. One of the latest considerations is that of Lemoine of Brussels, who made an extensive study of the normal and pathologic physiology of urination. The bladder receives its innervation from three sources: (1) Fibers of the thoracolumbar sympathetic which are distributed to the muscles of the urethra, the vesical trigone and urethra; (2) the sacral parasympathetic organovegetative fibers arising in the sacral segments to form the pelvic nerve, this nerve further on ramifying into two branches one of which becomes the vesical plexus. The fibers of this plexus end in the vesical terminal ganglions, so are known as postganglionic fibers, and these take their course through the muscular layers of the bladder wall; (3) in addition to the nerve connections there is a local vesical apparatus probably formed partly from nerve elements and partly from nodal tissue, which is intermediary between muscular and nervous tissue. From the physiologic point of view the intravesical nervous apparatus is made up of small reflex arcs, so it lies half way between psychic control and complete automatism, though partaking more of the nature of the second than of the first.

Physiology of Urination.—The act of urination is thus brought about as the result of stimulation of the nerves controlling the mechanism of the bladder musculature. When a certain amount of urine has been discharged by the ureters into the bladder, the increasing tension of the vesical wall is interpreted by the brain as the desire to void. Lemoine points out that the contracture of the vesical sphincter which

permits egress of the urine into the urethra is rendered largely automatic by habit and education, making the retention of urine in the bladder not a purely reflex act, but one which is under control of the superior centers. In order to overcome this opposition of the sphincter, the nervous impulses which maintain it must be inhibited, before those which act to contract the bladder wall can be stimulated to action, and this is exactly what takes place. The sphincter relaxes as the detrusor contracts and when the stream of urine has once begun to pass into the urethral orifice, it can be stopped before evacuation is complete only by a concentrated effort of the will, and in many individuals even this is impossible.

In general, voluntary control of micturition implies integrity of the afferent and efferent nerve paths of the bladder, as well as of those centers which have a share in the act of urination. Therefore, a lesion in the reflex arc will produce disturbances in urination such as difficulty in starting the stream, "stammering," or with much greater frequency in clinical practice, incontinence. The importance of an understanding of the innervation of the bladder will be demonstrated when we later take up some of these disorders of the urinary mechanism.

VESICAL ANOMALIES.

Extrophy.—That malformation of the bladder known as extrophy or ectopia vesicæ has already been mentioned in connection with abnormalities of the penis (page 130). It is a congenital anomaly consisting in the absence of the anterior wall of the bladder with deficiency of the corresponding abdominal parietes. Sometimes it amounts to no more than a slight exposure of a section of the trigone, but in most cases the cleft is far more extensive. At first sight there appears to be a split in the pubic region, but careful inspection will demonstrate that what appears to be a cleft is actually only a separation of the fibers of the recti muscles, usually confined to the mons veneris, but in some reported cases reaching up as high as the ziphoid process.

The essential factors in the condition would seem to be an error or arrest in the development of the anterior part of the allantois and the lower segment of the abdominal parietes. The symphysis is absent and the anterior part of the pelvic girdle deficient because the pelvic bones are not normally developed. This results in a wide separation below of the recti muscles, so that they find their insertion in the pelvic bones by passing obliquely outward. This forms a space roughly triangular in shape, into which the bladder is faced, so that it presents its posterior wall in the absence of the anterior one.[14] When extrophy is complete the symphysis will be separated for a distance of from 2 to 8 cm., the gap being filled in with connective tissue.[11] Between the separated fibers of the recti muscle the bladder

protrudes as a reddish, shining tumor standing up above the level of the surrounding abdominal wall.

Etiology.—The exact cause of extrophy is not known. By reference to what has been said concerning the fetal development of the bladder it will be noted that the allantois is the primitive urinary reservoir, and this, it will be recalled, takes its origin from the rectum, the accumulations from the kidney anlagen collecting in the primitive cloaca. Traumatic failure of union is suggested as a cause by Rose; Duncan, Tokitanski and Miller attribute it to the bursting of an over-full vesical. Moorhead[51] thinks the defect can best be explained on a mechanical basis, an intra-uterine rupture of a completely formed bladder. The first stage in the process is the closing-up of the urethra, causing retention of urine. The pubic bones, at this time scarcely cartilaginous, and still ununited, are kept apart until they become hardened. At the same time the rectus muscles are separated, so that little by little, by the intra-vesical pressure of urine, the bladder presses against the abdominal wall and finally ruptures and forms adhesions to the borders of the split.

According to Kaufmann, the secretion of urine does not begin until the end of the second month of fetal life; and the symphysis is formed before this period, which leads him to believe that the anomaly arises because of the failure of the symphysis to unite. Many other anatomists who are qualified to speak with authority regard ectopia vesicæ only as an instance of imperfect development, and it would seem in many cases, more especially those in which the cleft extends to the umbilicus, that it is due to an imperfect fusion of the two lateral halves of the abdominal wall.[7]

Coincident Anomalies.—Extrophy of the bladder is practically never the only congenital anomaly present in the subjects of this distressing malformation. In the male there is usually epispadias accompanied in many instances by absence of the prostate gland. Ectopia of the testicles is also a common accompaniment, in which event a deep furrow will divide the scrotum into two separate pouches. The proportion of males to females who are born with this defective bladder condition is about 5 to 1, but where it does occur in a female the urethra is usually wholly absent, the labia merely indicated rudimentarily, and the clitoris completely cleft, this cleft often continuing far within the genital canal, so that the subject is likely to present a bicornate uterus, and possibly a double vagina.

Grades of Extrophy. The various grades of extrophy have been thus classified by Winkel: (1) A defect of the bladder at its lower part, the pubis being united. (2) Fissura vesicæ superior, a defect in the upper part of the bladder, union of the pubis having taken place: this is a rare anomaly. (3) Typical ectopia of the entire bladder. All three types offer problems of the greatest intricacy to the surgeon who undertakes to correct any one of them, and any form of ectopia vesicæ is one of the most distressing anomalous physical conditions

which is compatible with life.[10] The urine, being of course, wholly beyond voluntary control, constantly trickles down the thighs, and no really satisfactory device has ever been contrived to collect it in such a way as to prevent the unfortunate victim of this deformity from

FIG. 137.—Typical ectopia of entire bladder. Wide separation of the symphysis pubis is noted.

soaking his clothing and continually emanating an unpleasant urinous odor. Walking is always difficult and can be accomplished only by spreading the legs far apart. A child so afflicted is shunned by other children, so that the effect upon character is very noticeable; he

becomes timid, morose, and in later years, often suicidal in tendency. One of Moorhead's patients was a boy, aged twenty years, who had never been able to wear trousers because of the exquisite sensitivity of the exposed vesical mucosa, and both this author's adult patients were illiterate, their deformity having prevented them from attending school.

Carcinoma of the Ectopic Bladder.—A case report of carcinoma of the extrophied bladder was made in 1924 by Murphy[52] at which time he found but 12 other cases in the literature. In an earlier report by Lower[49] we have another reference to the great rarity of the condition. Nine of the 12 recorded cases were in men, this proportion following quite closely that of the sex incidence of the anomaly. It is, on the whole, surprising that carcinoma should have been so infrequently observed in the extrophied bladder, inasmuch as the mucosa of the entire region is always subjected to much greater irritation and is far more exposed to trauma than in normally formed individuals. In Murphy's patient the adenomatous growth may very well have been a fetal remnant, originating from a deviation of cells from the cloaca, which normally would have gone over to the hind gut. Lower attributed the growth of the neoplasm in his case to the continual friction of a metal urine collector which the patient had devised for himself.

INJURIES TO THE BLADDER.

Traumatic Injuries.—In the great majority of traumatic bladder injuries, the lesion in this viscus is only part of a more extensive damage suffered by all the surrounding structures. Rupture of the bladder quite frequently takes place without simultaneous injury to neighboring tissues, but gunshot wounds and those occasioned by other implements of war, shell fragments wounds, bayonet thrusts, etc., must of necessity involve some trauma to the viscera nearby as well as to the bladder itself.

Associated Injuries in War Wounds.—In 52 cases of bladder injury encountered in war casualties, Colonel Andrew Fullerton[26] found associated wounds to the pelvic bone and rectum in 11 cases; to the pelvic bone and small intestine in 2 cases; to pelvic bone alone in 9 cases; to rectum alone in 8 cases; to small intestine alone in 4 cases, and in a single case, only the pelvic colon shared the bladder injury. As this author remarks, "The gravity of injuries to the bladder is greatly enhanced by associated damage to the adjacent structures."

Difficulties of Diagnosis.—All wounds in the region of the buttocks should be regarded with the utmost suspicion until their direction and extent have been carefully studied, for in not a few cases extraperitoneal wounds of the bladder or some nearby structure have wholly escaped discovery. One of Vance's patients[69] died eight days after being shot in the abdomen with damage to the fundus of the bladder and perforation of the intestine in eight different places. The cause

of death was infiltration of urine through a wound of exit from the bladder near the neck, which had been overlooked when the other perforations were repaired. Wounds near the vesical neck are most likely to escape notice because of the difficulty of examining this area with the ordinary cystoscope. If some time has elapsed between the receipt of the injury and the examination, the swelling and edema, or hemorrhage, may make it impossible to see the wound. If the traumatized area is very extensive, cystoscopy will often be wholly out of the question.

Symptoms.—Symptoms of bladder injury are often very indefinite at first. *Shock* is, of course, likely to be present as in any abdominal injury, but it is remarkable that the bladder may often be proved to have been severely traumatized, when early indications were trifling or wholly absent. In the case reported by Jack[40] the only marks of external violence were a moderate contusion of the perineum and a very small lacerated wound on the anterior surface of the scrotum near the median raphé, although the suprarenal and inguinal regions had a sort of boggy feeling on palpation. The patient's own story was "that he was only slightly intoxicated at the time of the accident, and that the front wheel of an automobile struck him in the perineum. He was knocked down but according to his statement, the wheel did not pass over him." Nevertheless laparotomy disclosed that the bladder had been torn into shreds. The author explains this by reference to the well-recognized fact that men under the influence of alcohol often go for long periods without emptying the bladder, and that while the collapsed bladder is a strictly pelvic organ which lies in a protected position, the greatly distended bladder is an abdominal organ and is thus much more subject to injury. Fullerton accounts for the comparatively few cases of explosive rupture among his military cases by the supposition that just before an attack the state of nervous tension practically always present will lead to an evacuation of the bladder contents; whereas, if the patient is caught unaware at other times, the organ may be in any state of distention.

Hemorrhage may be so severe as to prove shortly fatal, or the detection of blood in urine which the patient is able to void normally may be the first indication of the fact that any solution of the bladder's continuity has taken place.

Infiltration of urine is the most characteristic, as it is also the most grave manifestation of bladder injury. In gunshot injuries urine often appears at the external wound, or it may be more or less concealed in the form of extravasation into cellular tissue, or leakage into the peritoneal cavity. The urine may escape from the entrance wound, from the exit wound when present, or from a wound made by the surgeon for drainage or the recovery of a foreign body.

Extravasation of Urine.—Not always, when the urine has escaped from the bladder does it reach the surface; frequently it will be extravasated into the perivesical and perirectal connective tissues. Because

of the firm fibrous adhesions between the bladder and the rectum, this area is not likely to be so easily infiltrated.

Rupture of the Bladder.—Rupture of the bladder may be either intra- or extraperitoneal and Crosbie[18] has lately pointed out that many ruptures partake of the nature of both classifications. But it is probable that in at least 8 out of 10 cases of this decidedly unusual accident the rupture is intraperitoneal.

Spontaneous Rupture.—Spontaneous rupture has occasionally been reported, but this does not occur except in those bladders which present some pathological condition so that the vesical wall has been greatly weakened. Most of the "spontaneous" ruptures of the original diagnosis later on reveal a history of trauma which may have been so slight as to have escaped the patient's notice. Intoxicated men have often fallen, especially forward upon the face, and have later had no remembrance of any such occurrence, or given any visible evidence of it, yet the blow upon the abdomen has been sufficient to rupture a greatly distended bladder, especially if the bladder wall was not in a perfect state of resistance. This is an important point to bear in mind, as the symptoms of vesical damage are often too obscure to be of any practical value, and may likewise be produced by a number of other causes having no relation to bladder injury.

Extraperitoneal Rupture. Extraperitoneal rupture is most likely to take place in conjunction with injury to the pelvis. It results from severe violence directed against the suprapubic or perineal region, and when this violence is simultaneously exerted in both these directions, the bladder has small chance of escaping severe damage.[25]

The most frequent site of extraperitoneal rupture is in the trigonal space. Occasionally the tear may be in the preperitoneal tissues in front, space of Retzius, or very rarely, in the side of the vesical neck. If the pelvic bones have been splintered there may be a number of places where the sharp fragments have penetrated the vesical tissue. The extent of the urinary extravasation will, of course, be in proportion to the amount of damage sustained by the bladder wall. Fuller tells us that it has been his observation that as it increases in amount, the extravasated fluid, owing to a continuance of vesical distention or to pus formation from secondary infection, rapidly extends itself, so that after the extravesical space about the site of the rupture is filled, active burrowing follows.

Direction Taken by Infiltration.—It is the most dependent part of the extravesical space which will be first infiltrated, that is, the region occupied by the seminal vesicles behind the prostate, if the rupture has occurred at the base of the bladder, and even if higher up, the fluid will later on invade this region. Its course may be upward, mounting to the space of Retzius in the middle or both of the inguinal regions, or it may advance behind the peritoneum as far as the perinephritic tissues. In some instances even the thigh has been invaded, passing out of the pelvis under Poupart's ligament, generally exter-

nally to the internal iliac vessels, or it may reach the scrotum, following along and externally to the structures occupying the inguinal canal. Extravasations can break through the pelvic fascia into the ischiorectal space, the perineum or elsewhere, but the assumption of such directions is not to be expected unless the trauma causing the bladder rent likewise breaks down other structures which would otherwise act as natural barriers.[25]

Symptoms and Diagnosis.—Immediately after the trauma is inflicted there will be some blood in the urine, varying all the way from masses of clots which will obstruct the urethral opening, to such slight traces that only the microscope will reveal its presence. If the bladder neck is not lacerated, and large clots do not form, the patient is usually able to void, although there will be pain when the attempt to evacuate the bladder is made. This, however, may be so much less severe than the pain caused by the associated injuries that it will pass unremarked. So it is very often only when the extravasated urine has had time to burrow extensively into the surrounding tissues that the gravity of the vesical injuries is manifested.

The importance of differentiating between extra- and intraperitoneal injury is especially emphasized by Fuller, because "it is the cases of extraperitoneal vesical rupture that have not had the benefit of prompt surgery immediately following injury which . . . represent the large majority" of those seen by the surgeon. If measures to repair the bladder can be undertaken before the surrounding tissues have time to become infiltrated the chance of recovery is fairly good, leaving aside any consideration of the associated injuries. Where bladder injury is suspected the patient should be asked to empty the bladder, and his ability to pass urine which is not macroscopically bloody will be a fairly reliable indication that the bladder is intact. If unable to void, a catheter should be passed immediately and if neither urine nor blood comes away the probability of anuria due to shock is justified. If on repeated catheterization nothing can be obtained, however, it will then be necessary to employ the old-fashioned method of injection of sterile fluid in accurately measured quantity. This fluid is then withdrawn and measured to see how much has been returned. If little or nothing can be withdrawn a laparotomy to determine the extent of the damage to the bladder is justified. The cystoscope can be used in many of these cases, and this procedure in competent hands, with the improved types of instrument now in use, is certainly no more dangerous than the injection of fluid as outlined above. Of course, in many cases, the associated injuries and the state of the patient prevent cystoscopy, but where it is practicable it will be of great service.

Intraperitoneal Rupture, as has already been mentioned, not infrequently takes place without any associated injuries, and therefore presents problems or diagnosis and treatment which differ from those offered by extraperitoneal injuries. In little children especially, the

diagnosis is often very difficult, because such rupture is a very rare accident in childhood and the mere possibility of it is likely to be overlooked. But young patients as well as older ones may be "caught unawares"[38] with a full bladder, and even a trivial fall, as from a toy wagon may be sufficient to cause vesical rupture. As Crosbie has well expressed it: "The history of an injury to the lower part of the abdomen, which is followed by inability to void, should make one suspect rupture of the bladder; if a catheter shows a bloody urine, the probability is increased; while rigidity of the lower part of the abdomen is an indication for immediate exploration of the abdomen."

Gunshot Injuries.—When called upon to examine gunshot wounds in the region of thigh and buttock, the examiner should concern himself especially with the condition of the bladder, and in this relation, the position and direction of the wounds, and the locating of the missiles, if there is any reason to believe these have been retained, become of immediate consequence. By roentgenographic exposure, the condition of the involved bones can be ascertained, and the foreign body in many cases located; the use of the cystoscope shows missiles or bone fragments which have penetrated the vesical cavity and reveals any lesions of its lining mucosa. Rectal inspection will show any existing fluid accumulations in the pelvis or wounds or retained foreign bodies if the agent of injury has entered through this area. Leakage of urine into the peritoneal cavity may fail to give rise at first to acute abdominal symptoms, so that a careful watch must be kept on all doubtful cases. Fluid issuing from a wound in the parietes may be diagnosed as urine by its smell, by chemical examination, or by its becoming rapidly colored after subcutaneous or intramuscular injection of such substances as indigo-carmine or methylene blue. Fullerton points out that the leakage in injuries confined to the bladder is likely to be continuous and independent of micturition, whereas, when the urethra is injured, leakage occurs only during micturition unless the sphincteric apparatus of the bladder is also damaged. Fluid injected at the meatus readily escapes from the fistula, as a rule, in urethral injuries, whereas in bladder injuries this is not likely to take place until considerable pressure has been used and a larger amount of fluid has been injected. The distinction is of importance from the point of view of treatment. The integrity of the sphincter vesicæ is valuable in protecting the bladder from infection, especially if the urethral wound is made to communicate freely with the surface by an incision in the perineum.

Lodgment of missiles in the bladder is a comparatively unusual occurrence, indeed, up to the beginning of the World War, it was regarded as of the greatest rarity. During and since this conflict, however, case reports upon this subject have been considerably more common. Penhallow[57] of Boston, operating in England in 1915 has described the finding of a bullet free in the vesical cavity. The missile had entered at the median line of the back at the lower end of the

sacrum, and examination six days after the wound was received showed a firm sinus tract adherent to the rectum, passing around to the left, and then straight toward the bladder. No opening in rectum, no tenderness and no masses were felt. The urine was negative, save for a slight trace of blood and pus, while the cystoscope revealed no wound in the bladder wall, although a rounded mass lying just to one side of urethra was seen to move when the patient turned. The bullet was located by roentgenography and when removed by suprapubic cystotomy thirty-four days after injury, was somewhat encrusted with salts.

A similar case was reported by Turner,[67] an English military surgeon, and this same officer had seen several other cases where shell fragments and bone sequestra had penetrated the bladder wall and lodged in the cavity. In one patient a piece of shell-casing was carried by the outflow of urine into the urethra, gradually working its way through the entire length of the canal until it became impacted at the meatus. The symptoms caused by the peregrinations of this bit of metal were thought to be due to appendicitis, but after a fruitless laparotomy, urine began to flow from the wound in the buttock where the piece of shell had entered, and the true urinary tract condition was first suspected.

Other traumatic injuries to the bladder are discussed elsewhere, such as that due to stone (page 496) or the presence and removal of foreign bodies (page 498). The bladder may very easily be injured by careless or injudicious instrumentation, or, much less frequently, accidentally traumatized in the course of some operation upon adjacent organs, as in hysterectomy, or interventions upon the intestinal tract.

INFECTIONS OF THE BLADDER.

Gonorrhea.—It was the late John T. Geraghty who remarked that "while the gonococcus has a special predilection for the urethral mucosa of both the anterior and posterior urethra, the bladder, with the exception of the trigonal portion, is very rarely involved."[29] It has also been our experience that in most cases where a cystitis could be positively proved to be of gonococcic origin the infection would be limited to the trigonal region. It is a very rare thing to find a diffuse gonorrheal cystitis, and in general, the infections that can be exclusively attributed to this causal organism are by no means an everyday occurrence.

Cystitis following urethral gonorrhea is usually of a mixed type, for the gonococcus prepares the soil upon which other types of pathogenic organism find congenial conditions for growth. According to the observations of Lewis[47] when the gonococcus passes from the posterior urethra to the ureters and renal pelves, the transition is more often through the submucous lymphatics rather than by continuity over the vesical mucous membrane.

Tuberculosis of the Bladder. It is unlikely that tubercular cystitis is ever a strictly primary condition; the tubercle bacilli find their way into the bladder from a neighboring organ which harbors the original focus, so that it is infected either from below when the prostate, seminal vesicles or epididymes are tubercular; or by descending infection from the ureters and kidneys. The intact bladder mucosa seems to be more resistant to infection than is that of other genito-urinary organs, but when one considers the location of the urinary reservoir, lying as it does in the direct path of nearly all the bodily exudates, it can be a matter of no surprise that in the event of an invasion by the tubercle bacillus of any adjacent organ, the bladder is practically certain to contract a secondary infection. And not only may it suffer from direct continuity, but it is also liable to invasion through the blood stream and the lymph channels in the same way that tuberculosis is conveyed to other viscera.

Mode of Infection.—The mode of infection will, however, have some bearing on the particular area in the bladder which is attacked. Hematogenic infection is likely to manifest itself in the bladder walls rather than at the trigone, but if the disease enters by way of the lymph glands, especially in the event of an ascending infection from the male genitalia, the trigone is practically always the point of first attack. When renal infection already exists and the causal organisms descend through the ureter, the mucosa surrounding the ureteral meatus will be the area which will give the first indications of the spread of the infection to the vesical region.

Course.—Once the bladder becomes involved in a tubercular process the first cystoscopic evidence will be small areas showing congestion more or less intense according to the length of time the process has continued. If the infection has existed for some time tubercles will be in evidence, having a whitish angry appearance and soon breaking down into symmetrically round and discoid ulcers. Many observers have commented upon the remarkable symmetry of these round ulcers of vesical tuberculosis. "Even the confluent ulcers," says Coplin[16] "rapidly lose the isthmus which at one time partly separated them and quickly assume a roundish outline. The floor of the ulcer is shaggy, of a dirty yellowish color. It is uneven in contour but remarkably regular in color and shagginess. The diameter of the ulcer varies within wide limits;" they may be no larger than 1 or 2 mm. in circumference, and again may attain the size of that in the case examined by this author which was 7 cm., or about $2\frac{3}{4}$ inches in circumference.

The *disseminated form* shows tubercles distributed widely through the vesical mucosa, each tubercle being distinct, yellow or grayish in color, of the characteristic circular form and usually surrounded by a very narrow areola of inflammation of a brilliant red color.

Symptoms.—Frequency of urination is the primary, the most persistent and often the only symptom over a long period. This is due to irritation of the neck of the bladder, but no pain will be felt

PLATE VIII

Bullous Œdema of the Right Ureteral Orifice

This condition is usually present in unilateral tuberculosis, but may occur in any type of renal infection. It indicates a rather acute infection to which the mucosa of the bladder has reacted.

until long after this irritative process is begun. If no secondary infection has been superimposed upon the tubercular cystitis it may be several months before slowly increasing pain, and the fact that he is obliged to rise several times during the night to urinate, directs the patient's attention to his bladder condition. Hematuria may be early in evidence, but in some cases the ulceration which produces it does not take place until the process has been continuing for a long time. In any event the evidence of blood in the urine will not be continuous, only at intervals imparting a reddish tinge to the urine. Profuse hemorrhage following micturition usually implies ulceration of the bladder.

FIG. 138.—Tubercles of the bladder mucosa in the region of the ureteral orifice. This stage represents a more chronic condition than that noted in Plate VIII, and precedes the ulcerations which are a fairly late manifestation in bladder tuberculosis.

Diagnosis.—*Examination of the urine* is a most important part of the attempt to establish a diagnosis. The first variation from normal will be the occasional traces of blood; otherwise the voidings will be clear, and it will be only upon minute microscopic scrutiny of the products of careful centrifugation, that a suspicion of the true state of affairs will be aroused. Often the tubercle bacilli will not appear until late in the disease, though usually they can be detected by diligent search before any other symptoms point toward tuberculosis as the cause of the frequency and vesical pain. Later in the course of the disease, the urine will become clouded, and shreds, pus cells and strings of mucus can be easily detected. Hematuria becomes more frequent and persistent also. The final diagnosis must rest on the observations made through the cystoscope and the positive demonstration of tubercle bacilli in the urine. Guinea-pig inoculation will often serve to clinch the diagnosis.

When the tubercular process has advanced very far the vesical walls

will become thickened as a result of the inflammatory reaction, and the bladder capacity will be continuously lessened until it will hardly be able to contain more than 2 or 3 ounces of urine. The condition of the patient becomes most pitiable, micturition becoming exquisitely painful and the necessity of emptying the shrunken bladder being so urgent that he must pass his urine three or four times an hour.

Treatment. The older clinicians advocated various sedatives and urinary antiseptics for the alleviation and control of tubercular cystitis; such drugs as guaiacol and creosote being perhaps the most esteemed among the first, and salol, salicylic acid and several others being thought useful for the second purpose. Today, however, little dependence is placed upon drugs for other than purely palliative purposes. It is recognized that tuberculosis of the bladder, as of other parts of the body, must be combated by the general hygienic and dietary measures which have proved efficacious in the treatment of pulmonary tuberculosis, and that the vesical infection is generally only an extension from a preëxisting focus, and once that focus is eradicated, the bladder condition will improve without further treatment. This has been repeatedly demonstrated following the removal of a tubercular kidney; even severe cystitis quickly clearing up when the continuous stream of infection from above has been permanently cut off. Instrumentation of any kind is likely to do more harm than good when the bladder is infected by tubercle bacilli, so that irrigations should be avoided whenever possible.

Surgical measures have occasionally proved beneficial in cases where there was an extreme degree of ulceration. Guyon, the great French urologist, used a suprapubic incision, through which he curetted the affected areas, swabbed them with bichloride of mercury solution, and established drainage for as long a period as seemed desirable, but in our opinion any such intervention should be avoided whenever possible, and reliance placed upon general constitutional measures and the removal of the source of infection.

Colon Bacillus Infection.—The colon bacillus is generally accepted as being the most frequent cause of the cases of cystitis encountered in the general run of practice, and even when some other organism can be identified as accountable for some of the disturbance, the colon bacillus will be found present as well, and often by the superimposition of a secondary infection, serve to greatly complicate the clinical picture. The effects of the invasion of the bladder by this organism vary widely, in one case perhaps, being associated with inflammation so intense as to advance almost to a gangrenous condition; while in another case, presenting equal opportunity for virulence, the infection will be of a very mild grade.[29]

Grades.—The mild form of colon bacillus cystitis, often termed "catarrhal," usually has its seat in the trigonal region or around the ureteral openings. If left untreated this will quickly advance to a more severe interstitial form, involving a considerable extent of the

bladder wall, which becomes thickened and edematous, often passing on to the formation of bullæ and eventual ulceration. It was Geraghty's observation that if, on cystoscopic examination a localized area was found where the mucosa appeared more white than normally, the tissue looking scarred and puckered, one can feel reasonably certain that no local applications will afford relief. If again there is present an evident mucosa lesion which seems to respond to the local applications but without improvement in the symptoms of the patient, one can be reasonably certain that there is deep involvement of the bladder wall. Under these circumstances, the capacity of the bladder may be so reduced so that it will hold scarcely more than a couple of ounces of urine.

Symptoms.—The symptoms are those of practically all bladder affections, so that colon bacillus cystitis cannot at first be differentiated. Increasing frequency, pain on micturition, urgency and in the more advanced conditions, hematuria, are in evidence, but in no way characteristic of this particular infection. Pyuria is, however, a constant symptom, and the diagnosis must, of course, finally rest upon the results of urinalysis. All the receptacles, whether one, two or even more are employed, will be heavily clouded, with blood and epithelial cells, while the causal organism will usually be readily detected, being present in large quantity. Lewis notes that the thorough diffusion of the clouding is in marked contrast to that observed when the pus is of renal or pelvic origin. In these affections the pus settles rapidly to the bottom of the glass, making a thick belt of sediment with sharp demarcation from the comparatively clear urine above it. On the other hand, bladder inflammation, especially when due to the colon bacillus, will show pus cells and strings of mucus, which are usually perceptible even to the inexperienced without microscopic aid.

Treatment.—The colon bacillus usually produces an acid cystitis so that measures to correct the acidity of the urine form a large part of the physician's curative efforts. The bladder must be freed from as large a measure of work as is possible, which can be accomplished by the liberal use of sedatives, including morphine, or pantopon, as suggested by Geraghty, and restriction of the quantity of fluid ingested to the least amount with which the patient can be kept contented. This second measure will so reduce and concentrate the urine that alkali must be administered to counteract the urinary acidity. In the mild cases, irrigations with silver nitrate or other silver salt in appropriate solutions, will prove effacious, but when the inflammatory process has invaded the underlying tissues more rigorous measures will have to be employed. Resistent areas of cystitis may yield to the following method: The bladder is first filled with salt solution, the operating cystoscope is passed, and through it an ordinary ureteral catheter without the side eye and with the end cut square, is inserted in the bladder. The catheter tip is directed to the spot upon the vesical wall which it is proposed to treat, and a 10 to 20 per cent solution of

silver nitrate injected directly upon it. This enables one to employ a relatively strong solution exactly where it is desirable to apply it, without irritating the remainder of the bladder mucosa. A silver nitrate point may even be fused to the catheter tip, which under these conditions must be of metal, so that the infected area can be directly painted.[29]

Surgical measures applied to the ascending colon have been recommended for the relief of persistent colon bacillus cystitis,[50] acting upon the theory that continuous reinfection is taking place because of stasis of the fecal current. Such stasis may be due to immobilization of the cecum, because of adhesions which have formed between it and some adjacent organs, and from this point a constant supply of colon bacilli enter the circulation through the lymphatics in the kidney capsule, or by the blood stream, and primarily infect the kidney pelves on their way out, if there is any interruption to the free exit of urine, either in the ureters, at the neck of the bladder, or in the urethra. Once the infection is established, it is practicably incurable until a normal condition in the large intestine, or one approximately normal, is restored by surgical measures.

Vesical Syphilis.—Tabetic Bladder.—It was for many years very generally believed that the bladder never partook of the infection resulting from syphilitic invasion, and this opinion was so firmly rooted that, in this country at least, many authoritative text-books passed over the subject in silence, and even today, it is difficult to find any adequate treatment of the subject outside of periodical literature. The thesis presented at Paris in 1913 by Duroeux[20] seems to be the first extensive review of the scattered reports concerning vesical syphilis, but this has received little attention in this country, and would seem to be unknown to the great majority of urologists. In this thesis we find an interesting summary of the Continental literature, beginning with a reference by Morgagni in 1767, who described a postmortem specimen, the diagnosis being confirmed by undoubtedly luetic lesions found elsewhere in the body. Follin in 1849 and Ricord in 1851 were the next to present cases and describe the characteristic lesions, and a little later other reports were put forward by Virchow and Vigal de Cassis. The cystoscope appears to have been first used for the diagnosis of vesical syphilis by Matzenauer in 1900. In all, Duroeux collected 26 cases of tertiary vesical syphilis, and 14 secondary cases, the majority of which had been recorded by French observers, but when we consider the difficulties of diagnosis, and the uncertainty which up to a very short time ago, clouded all work upon leutic infection, it immediately becomes evident that this paucity of literature is much more likely due to failure to observe and recognize than to actual infrequency of occurrence.

Difficulty of Recognition.—The cystoscopic appearance of vesical syphilis closely resembles that of lesions much more commonly recognized, hyperemia, simple ulcer or papillary growths, for example.

The classical hyperemia of vesical syphilis however, presents a roseola of the bladder; scattered, discrete reddish spots, having the general characteristics of macules; but even with this appearance there will frequently be no symptoms whatever. The characteristic ulcer is described as practically identical with the typical syphilitic ulcer as it appears upon any mucous surface, more or less elevated from the surface of a mucosa edematous and injected, the edges being very sharply defined, projecting and indurated; the base of a grayish color and surrounded by necrotic débris. These ulcers usually appear in groups, so that they should be reckoned as multiple, but they are only rarely disseminated to any great extent, being most often gathered about the ureteral orifices. As this is a location where tubercular ulcers often appear, and the symptoms which they produce, frequency, urgency, pain on micturition, tenesmus and bloody urine, are likewise characteristic of vesical tuberculosis, there is always a strong probability of confusion in making the diagnosis.

Papillary Growths and Gummata.—When viewed through the cystoscope, there is nothing about the papillary growths of luetic origin to differentiate them from those due to other causes, nor from the villous growths which arise from a malignant base. The same difficulty of recognition attends the appearance of the gummata of tertiary bladder syphilis. It is an infiltrating growth which may very well be mistaken for a malignant one, and offers no characteristic features which can serve to guide the cystoscopist in any way.

Diagnosis.—It is thus evident that the diagnosis cannot be made by dependence upon the cystoscopic findings alone. The syphilitic nature of the process will have to be established by corroborative evidence—the history, Wassermann reaction upon both blood and spinal fluid, and even perhaps the effect of antiluetic treatment. That luetic ulceration may exist in the bladder without producing any symptoms referable to the urinary tract was demonstrated by Duroeux, who, working in association with Levy-Bing in 1912, made a routine cystoscopic examination of 100 syphilitics, in 1 of whom they found a number of small bladder ulcers, although the patient had never displayed any urinary symptoms; the Wassermann reaction upon his blood was, however, positive, and he presented other undoubted evidences of syphilis.

In a number of the reported cases retention has occurred, because of the occlusion of the urethral orifice by clots, sometimes so completely as to prevent catheterization, making a resort to suprapubic cystotomy necessary in order to drain the bladder.[58] Even when catheterization is possible, the clots and continual oozing may make cystoscopy difficult if not altogether out of the question.[55]

Tabetic Bladder.—Parasyphilitic affections of the bladder are those which, although they show no luetic lesion in the bladder proper, are none the less due to the effects of syphilis upon the central nervous system.[64] Tabes dorsalis often thus gives the first evidence of its existence; Paul Asch, for example, having reported a case where the bladder

symptoms preceded the other classical tabetic signs by ten years. Frequently a patient will present himself to the physician because of incontinence, usually nocturnal, and the examination will then reveal the presence of the other classic signs, up to that time entirely unnoticed. There is considerable question of the advisability of pushing antiluetic therapy under these conditions. While the bladder symptoms are sometimes abated by such treatment, the fact remains that they are due to the damaged state of the spinal cord, and these lesions even should the syphilitic process be wholly stopped, cannot be expected to disappear. Moreover it seems more probable that the degenerative processes once set in motion, will continue even if the causal factor is removed, and it thus becomes evident that any therapy directed toward the vesical condition, cannot be of great or permanent value.

VESICAL NEOPLASMS.

The usual classification of neoplasms into benign and malignant is not so readily made when the new-growths under consideration are located in the bladder, because accumulated clinical experience has shown that the majority of vesical tumors are originally benign, but that these innocent growths have a decided tendency to become progressively malignant, and if removed, are prone to recur in a malignant form. Males are far more likely to be afflicted with this particular neoplasm than are females, the proportion being something like 3 to 1. In childhood we are likely to encounter sarcomatous growths which evince a very rapid growth and are almost universally fatal within a few weeks; in early adult life the papillomatous type of growth is most frequently seen, while in the fifth and sixth decade, at the "cancer age," we find the carcinomatous tumors of the bladder.

Benign Growths.—Benign growths are usually attached to a pedicle and project outward into the bladder cavity; they arise around the ureteral orifices or upon the trigone, and are thus more accessible to observation or efforts at extirpation. The pedunculated, polypoid tumors have been described by Lewis as varying from soft, filmy, fimbriated masses floating freely in the fluid, to firmer, cauliflower-like bodies, attached to the bladder wall by pedicles of greater or less size. Braasch[8] has called our attention to a papillomatous proliferation of the mucosa which may sometimes be detected on cystoscopic examination. Such tumors are found more often near the ureteral meatuses or the internal vesical sphincter, and although they are probably the result of a slight chronic inflammatory reaction of the mucosa, no other evidence of inflammation may be visible. They may disappear spontaneously, but they will occasionally remain stationary in size for a period of several years. It is quite possible that some of these are the forerunners of papillomatous or malignant tumors, which is further suggested by the frequency with which malignant tumors are

found near the ureteral meatuses. Such tumors when discovered should be removed at once by fulguration.

Chronic inflammation, if of a sufficiently severe type, may induce such extensive proliferation of the mucosa as to easily deceive the cysto-

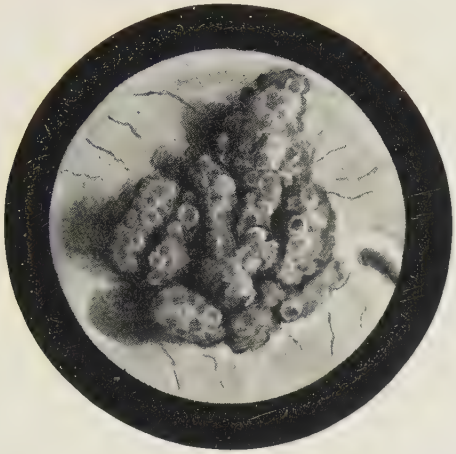


FIG. 139.—Benign pedunculated polypoid tumor occurring just above the right ureteral orifice. A mass such as this bleeds easily, and in some neglected cases has almost exsanguinated the patient.

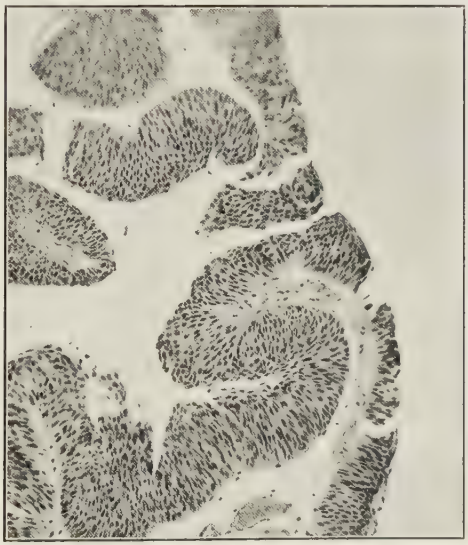


FIG. 140.—Microscopic section made from tissue removed from benign papilloma of the bladder with Lowsley operating cystoscope. It will be noted that the cells are arranged in regular rows, and at no point have broken through the basement membrane. The bloodvessels are numerous and large.

scopist into believing that he is looking at a true vesical new-growth. Tuberculosis of the bladder is especially likely thus to affect the mucosa, thus adding to the confusion in diagnosis which is prone to attend so many vesical conditions.

FIG. 141.—Papillomatous proliferation of the vesical mucosa which is the result of long-continued irritation. These areas usually occur in the region of the ureteral or vesical orifices. They are easily destroyed by fulguration, and should be so treated, as there is a possibility that they may be forerunners of benign papillomata, or even of papillary carcinoma.

Malignant Neoplasms.—Malignant vesical neoplasms are more likely to infiltrate the bladder wall, often indurating it to such an extent that the "board-like hardness" may be readily palpated through the rectum or vagina. Viewed through the cystoscope they are commonly sessile, with broad attachment and involvement of vesical structure; of rugged, ulcerated surface, with gaping fissures, from which blood may be oozing at the time of observation. In contrast to the free motility of the relatively benign growths, they are quite immovable. Beer[5] has noted that there is often more or less necrosis of the papillary masses and exudate visible upon them, when the growth is malignant; there is also a much more solid union of the fronds so that the tumor looks like a mixture of solid and papillary growth; the mucous membrane which lies beneath it, and that covering adjacent tissues is frequently edematous, and thrown into folds suggesting a blockade or an involvement in the lymph channels of the mucosa and submucosa. According to Scholl[59] the majority of squamous-cell carcinomas of the bladder are flat and ulcerated, extensively involving the vesical wall, and in most of the cases he has observed the symptoms do not give a correct indication of the extent of the condition. Metastases do occur, but not so frequently nor so extensively as the extent and appearance of the local lesion would indicate, and when they are present are likely to be found only in the local lymph area. The squamous-

cell carcinoma is not a common bladder neoplasm; of 333 vesical tumors seen at the Mayo Clinic during a ten-year period, only 6 were of this type of growth.

Symptoms and Diagnosis.—There is but one invariably symptom which *may* indicate the presence of a bladder tumor, and that is hematuria, but when we pause to consider how great a variety of pathological conditions to which the bladder is subject present this same symptom, its value seems almost negligible. In this connection, however, it may be well to emphasize the great importance of *not* falling back upon a diagnosis of "essential hematuria" until the possibility of tumor has been eliminated beyond all shadow of doubt.

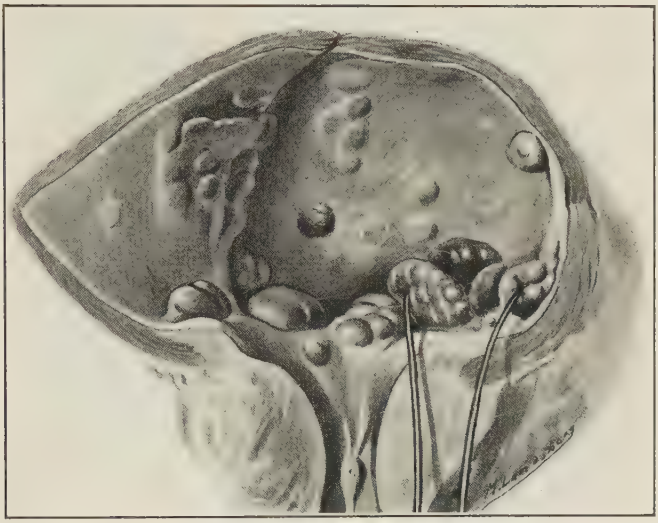


FIG. 142.—Multiple carcinomata of the vesical mucosa. This is rather a rare condition. Ordinarily there is a single growth which attains a large size. Later on, one or more new growths may appear. In this specimen there were 38 separate tumor masses.

We have no means of knowing to how many unfortunates this pronouncement of "essential hematuria" has been a sentence of death from the excrutiating agonies of vesical malignancy, but it is certain that there have been a vast number. With the instruments which are at present ready to the hand of even the general practitioner, there should be no hindrance to an investigation which will fix the origin of the bleeding, if it does proceed from a bladder neoplasm. If the condition is far advanced, the whole urinary tract may be so exquisitely sensitive as to render any examination impossible without preliminary anesthesia. For this purpose the sacral method of anesthesia can usually be employed with the greatest satisfaction both to examiner and patient. Profuse hemorrhage from the growth may also interfere

with proper observation of the pathological conditions present, but this can usually be overcome if the instrument employed affords sufficient free irrigation, or a solution of suprarenal extract, or some other styptic agent may be injected into the bladder just before the examination is undertaken.

The close resemblance of the cystoscopic pictures of tuberculosis, syphilis and malignancy of the bladder, must of course, greatly increase the diagnostitian's difficulties. The importance, in so far as prognosis is concerned, of early recognition of any malignant condition, augments

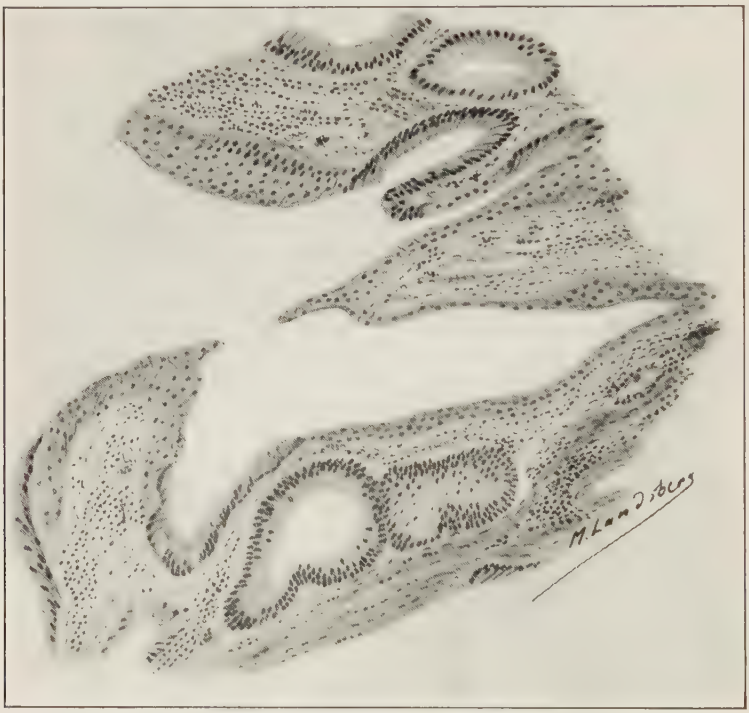
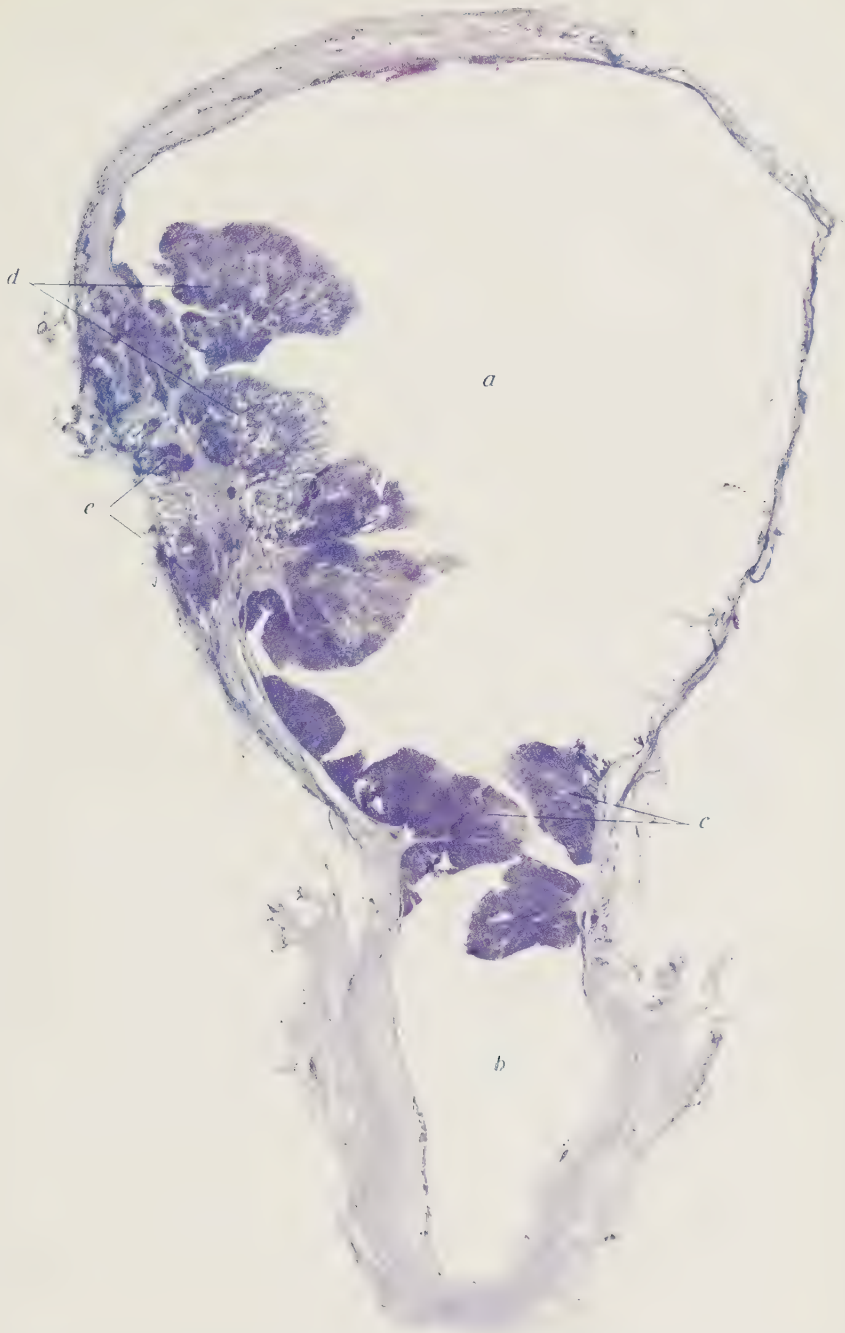


FIG. 143.—Microscopic section of squamous-celled carcinoma of the urinary bladder.

still further his responsibility, and the reluctance which must be felt toward excision of tissue for microscopic exmination, places still another barrier in his way. Judd[43] notes that a superficial carcinomatous ulcer of the bladder has much the same appearance as an epithelioma of the lip. "It is slow-growing and very slow in metastasizing . . . The penetrating carcinomatous ulcer appears more like the carcinomatous ulcer common to the rectum." To one who has familiarized himself with the appearance of malignancy under various guises, the detection of the malignant bladder growth should not be an excessively difficult procedure.



Infiltrating Papillary Carcinoma of the Bladder. Microscopic Frozen Section Through Entire Organ.

Made by Prof. E. Christeller of Virchow's Krankenhaus and presented to the authors for use in this book. *a*, Lumen of bladder; *b*, lumen of urethra; *c*, papillary carcinomatous masses at the neck of the bladder—these do not show any invasion; *d*, older growths with large pedicles; *e*, invasion into and entirely through the bladder wall by the carcinomatous masses.

Prognosis.—The prognosis of any form of bladder tumor cannot be regarded as cheerful, though many cases of apparent cure are on record. The early benign growths are quite easily removed, but they recur with discouraging frequency, and these recurrences, as has already been noted, are more than likely to prove malignant. Malignant growths which have infiltrated the bladder wall, are naturally, much more difficult to extirpate, and although vesical growths are perhaps not so prone to metastasis as those in some other location, secondary deposits

FIG. 144.—Cystogram of a large carcinoma of the right side of the bladder, with several smaller growths on the opposite side higher up. This is a beautiful example of a filling defect, caused by the mass displacing the sodium iodide which was introduced into the lumen of the bladder.

are likely to spring up where the previously intact mucosa has come in contact with the malignant areas when the bladder is relaxed and more or less folded upon itself.

Treatment.—Treatment has undergone marked progress during the years immediately past. Until very recently extirpation was the only hope that could be offered, with occasional total extirpation of the bladder and transplantation of the ureters, a procedure attended by a lamentably high percentage of failure. About 1910 Beer introduced

his fulguration procedure which has proved highly efficient in the removal of benign growths, and the improved methods of applying radiotherapy have made this a most efficacious means of dealing with even the most malignant growths, if they have not advanced too far before coming under observation. In general, non-operative measures are rapidly supplanting surgery, and the time is possibly not far distant when the knife will be wholly superseded by more conservative means.

CALCULUS AND FOREIGN BODIES IN THE BLADDER.

"Stone in the bladder" is undoubtedly one of the oldest surgical conditions of which we have records of attempts at treatment. Indeed, the history of surgery during the middle ages at least, is almost entirely a record of these attempts, and the consideration of this subject, viewed from many different angles, looms very large throughout all early medical literature.

Etiology.—Many causes have been cited as accounting for the formation of vesical calculus, and it is probable that all of these have, in one case or another, had some bearing on the production of these concretions. The observations of many centuries seem to concur in attributing to particular localities and races, or perhaps more exactly, the dietary and other habits of certain races, especial facility in their production, and the association of stone formation with hereditary physical tendencies, the "uric acid diathesis" which so interested our professional forebears, is far too well authenticated to be ignored.

Alkaline fermentation has long been recognized as favorable to the production of bladder stone. Where a condition of chronic inflammation has existed for a long time, the urine invariably becomes alkaline, with resulting formation of triple phosphates and other alkaline salts. Any condition which causes retention, so that residual urine is constantly present in the bladder, will strongly influence the precipitation of salts with subsequent calculus formation. The hypertrophied prostate is perhaps the best example of such an agent of retention. If the bladder cannot be fully emptied at each micturition, particles of precipitate will likewise be retained which would easily pass out through the urethra if the conditions in that duct were normal, so that there is an additional impetus given to stone formation. Renal and ureteral stones, formed higher up in the urinary tract and passed downward will be considered later (pages 560 and 633).

Symptoms. The symptoms vary greatly in their intensity. Occasionally a stone will attain a large size without causing any symptoms whatever, and again, the irritation caused by the presence of very small concretions may be so great as to urge the patient to seek immediate relief. Cystitis from any cause will induce increased frequency of urination so that this is usually the first observable symptom after calculus formation has taken place. Tenesmus may be marked, the

spasm sometimes even involving the rectal wall. The impulse to urinate is likely to be lessened when the patient lies down, so that the frequency will diminish at night, whereas in other conditions inducing this same symptom, prostatic hypertrophy for example, the frequency is more annoying and urgent at night than during the hours when the patient is upright. Walking, on the other hand, increases the difficulties of the victim of calculus formation.

Pain is practically always in evidence, and is always aggravated by motion. Often such a patient cannot ride in an automobile without positive anguish, but when the body is at rest, will be comparatively comfortable. When the bladder is being evacuated, the outflow of urine often sucks the stone down into the urethral orifice, which may suddenly cut off the stream altogether and produce a pain as sharp as a knife-thrust. Even when this does not occur, the gradual collapse of the evacuated bladder upon the stone is likely to induce irritation

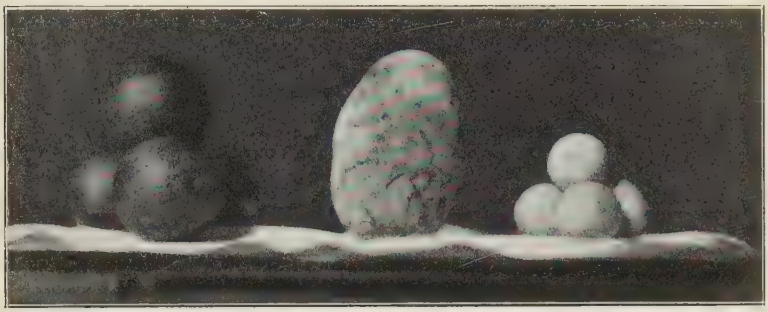


FIG. 145.—This large stone was removed from a patient in the Royal Victoria Hospital of Montreal by Dr. David W. MacKenzie, and is reproduced here by his permission. A fair idea of its very large size is noted by comparing it with the golf balls piled on one side of it and the oranges on the other.

at the end of every act of micturition, and this is usually felt by the patient as a stabbing or pricking, often radiating along the urethra, or referred to the end of the penis; the pain may even be referred to the lower bowel, and the complaint be of a sensation like "passing a paper of pins." Rarely, there may be reflex pains in distant parts of the body, the legs, sometimes as far down as the feet, and in a few cases even to the arms and shoulders.

Diagnosis.—The diagnostic signs are not very characteristic; the peculiarities of the pain just recited, being perhaps the only marked differential point. As the presence of stone will induce cystitis, we will be presented with the evidences of that condition, which do not vary greatly from those of cystitis due to other causes. The urine will sometimes be quite clear in appearance, but the microscope will reveal pus and red-blood cells, and if alkalinity is marked, the pus will be stringy and stained with blood from the inflamed mucosa. If

the amount of blood detectable in the urine is greatly increased after exercise or prolonged motion of any sort, and decreases or wholly disappears when the patient has been completely at rest for some time if should be regarded as highly significant. If the calculus is large with an exceptionally rough surface it may traumatize the mucosa every time the bladder is emptied, so that the end of each micturition will be accompanied by a show of fresh blood.

Examination may be conducted in a variety of ways. Palpation through the rectum or vagina may sometimes at once reveal the presence of calculus. "Sounding for stone" is a very ancient exploratory procedure, and is still employed by many urologists as a routine diagnostic procedure. The cystoscope is today, however, the main instrument upon which the urologist places reliance, and with the improved types now available it is possible to examine the entire vesical cavity without much chance of overlooking the object of our search. If a stone is very small it may not give any impulse when it comes in contact with a searching instrument, and it may also be so encased in mucus or clotted blood that its characteristic "feel" will be wholly disguised. Calculi encysted in the bladder wall, or packed into a diverticulum (page 501) may remain securely hidden from even the most practiced hand and eye, though a well-trained cystoscopist is not often led thus astray. Radiography will in practically all cases solve the question when other methods have failed. The author's instrument elsewhere described (page 97) will prove most useful in handling cases of this type.

Foreign Bodies.—**Etiology.**—The list of foreign bodies which have been detected in the human bladder and successfully removed from it, is an almost incredibly long one. Probably the greater part of them are introduced by masturbators into the urethra, whence they escape during the engendered sexual excitement, so as to be beyond the reach of the introducer, whose frantic efforts to retrieve them only accelerates their passage into the bladder. Once there, shame usually prevents the victim from seeking aid in their removal, and as in most cases there are no immediate symptoms, the presence of the foreign body may actually be forgotten until the gradual encrustation of urinary salts so increases the bulk of the intruding substance as to set up a chronic cystitis and probably make an impediment to the outflow of urine. Hair pins and hat pins have been recovered under these conditions in a long array of cases, frequently a suprapubic cystotomy being the only means of extracting them.

Surgical accidents are accountable for a small proportion of vesical foreign bodies. Catheters and other instruments may be broken off, the fragments working their way into the bladder cavity; sutures have occasionally sloughed their way through the vesical wall, and becoming encrusted formed formidable foreign bodies; fragments of bone, or even the entire skeleton of an ectopic fetus have occasionally invaded the bladder cavity.

Swallowed bodies such as tacks, nails, bits of glass, etc., have been recovered from the bladder, the subjects usually being small children or insane adults. Sterling Bond[6] removed from a pocket in the postero-superior portion of the bladder, from 80 to 90 nails varying from 6 to 16 penny, weighing 350 gm., together with 20 gm. of cobbler's nails and carpet tacks; 1 roofing nail; several pieces of glass, the largest of which was $\frac{1}{2}$-inch in breadth and $\frac{3}{4}$-inch in length; bits of stone; a piece of enamel from a tooth; 1 carpal bone of a small animal, and 2 3-inch screws. The patient, a colored man aged fifty-eight years, reacted well from the suprapubic removal of this varied assortment of hardware, but the symptoms continuing and necessitating a second operation, the withdrawal of "from 30 to 40 tacks" lodged in the postero-inferior portion of the bladder just above the trigone, proved too much for him. The autopsy showed a fistula from the ileum to the bladder, the perforation in the ileum being evidently of long-standing.

VESICAL DIVERTICULUM.

Literature.—Though our knowledge of vesical diverticulum is at present extended, up to a comparatively recent period there was but little authorative literature upon it, and this was practically all in French, or at least in languages other than English. The first general review of the subject in our own tongue appears to be that of Fischer[23] published in 1910. In this paper he cites an excellent and thorough study in the thesis of Alcée Durrieux who, up to 1901, besides his own case, collected 194 observations. In Germany, Pagenstecher, Englisch and Wagner have contributed to our knowledge. A number of excellent French papers have appeared since the World War, those of Legueu and Papin,[46] of Gayet and Gautier,[28] and the thesis of Busson,[12] being especially noteworthy. Negro and Blanc[53] very recently reported 30 cases from Marion's clinic and among out-standing contributions in our own country are the studies of Hinman[35] and of Judd and Scholl[42] of the Mayo Clinic.

At the beginning of the present century, Durrieux,[21] writing of vesical diverticulum, has given us the following definition: Diverticula are cavities of a certain nature, closely connected with the bladder and resulting from an expansion of a portion of its walls. They are characterized by: (1) The presence of a clearly-defined opening which forms the communication between the cavity of the bladder and that of the diverticulum. (2) Absence of a ureteral opening. (3) A mucous lining which is continuous with that of the bladder and covers the whole inner surface of the pouch.

Classification.—In accordance with the most generally accepted classification of vesical diverticulum, it may be regarded as of two types, congenital and acquired. The congenital type exists from birth as an anomaly of development; the acquired type develops after birth, presumably as the result of urinary back-pressure. According

to Thomas[66] the congenital may be subdivided into (*a*) hour-glass bladder, the strangulation either above or below the ureters; (*b*) double, split or bifid bladder, where the separation may reach to the apex of the trigone, but both cavities open into a common urethra, or a double urethra may be present. The acquired type may be subdivided into (*a*) intra-uterine; (*b*) produced by obstacles to urination, this is by far the most frequently encountered; (*c*) traumatic.

Etiology.—Much has been written of late regarding the etiology of bladder diverticulum, and authoritative opinion is still very much divided. Hinman, for example, is convinced that all diverticula are acquired, the result of the interaction of various factors, anatomical, pathological and mechanical. The anatomical arrangement of the

FIG. 146.—Cellules of the bladder wall produced by the endeavor of that viscus to empty itself when partially obstructed. The muscle bundles of the vesical wall hypertrophy to such an extent that there are spaces lined with mucosa between them. Some urologists believe that occasionally one or more of these cellules enlarge to such an extent that they break out entirely beyond the bladder wall and become diverticula of the acquired type.

inner longitudinal muscle layer of that region of the vesical wall which lies above the ureteral orifices, the ligamentum interuretericum, in its relation to the fixed portion of the trigone, renders this portion of the bladder functionally disposed to herniation. Changes in the bladder wall leading to muscular insufficiency at points of anatomical weakness, and urinary back-pressure which will aggravate it, constitute the pathological factors in the production of diverticulum, and any condition of obstruction demanding an increased effort on the part of the bladder, will materially exert a mechanical effect upon those pathological changes in its wall.[35]

An opposite view is taken by Judd and Scholl, who believe that vesical diverticula are primarily embryological defects in the bladder,

either a weakening of the musculature, usually at the base of the bladder, or a definite hiatus in the vesical wall, though the actual distention and dilatation of the sac probably result in most cases from obstruction to the bladder outlet.[42]

Clinical Picture. It is probable that true congenital diverticula often remain unrecognized throughout life, and in many cases produce no symptoms until the subject has entered or passed middle life. Frequently however, most serious pathological changes will take

FIG. 147.—The small orifice of a very large diverticulum is noted just above the left ureteral orifice. This diverticulum had a capacity about one-half as great as the bladder itself. The regions of the ureteral orifices are favorite sites for the orifices of diverticula. Occasionally the ureteral orifice will be located inside the diverticulum. The authors have one such case and are able to insert a catheter into the ureter for the purpose of securing specimens and administering treatment.

place. The urine which is retained in the pouch eventually decomposes and proves highly irritating to the mucous membrane. This inflammation may go to complete gangrene of the mucous membrane, or even of the muscularis, with perforation into the peritoneal cavity and subsequent purulent peritonitis. The development of stones in the diverticulum is frequent.

Symptoms indicating the existence of diverticulum are, on the whole, rather vague. In three-quarters of the cases collected by Hinman, the initial symptom was difficulty or frequency of urination. In 13

of 152 cases, hematuria is mentioned as the first symptom, while in 6 it was cystitis or pyuria, acute retention in another 6, pain and burning in 4, pain in the abdomen and in the bladder in 3 each, and pain in the lumbar region and chills and fever in 1 case each. In general, the symptoms are those common to the condition of prostatism.

Pain may be in the abdomen and described by the patient as a sensation of pressure or fullness; or it may be no more than a sense of stinging or burning, during and after micturition. Usually when the act is completed there will be a feeling that the bladder contents has not all been voided; occasionally complete retention will be the first manifestation of the condition.

FIG. 148.—This roentgenogram shows the cystoscope in the bladder, a catheter coiled in a diverticulum of the left side of the bladder, and a diverticulum on the right side, partially filled with sodium iodide.

Urine.—As soon as the urine begins to stagnate in the pouch, examination of what is voided will show that it is clouded and loaded with muco-purulent material; not infrequently hematuria will be present. In more than 60 per cent of Hinman's collected cases some or all of these symptoms had been present for as long as five years.

Diagnosis.—*Examination* will usually disclose a mass above the symphysis which may be on either side of the bladder. Or if the diverticulum is situated in the anterior part of the bladder, palpation in the rectum or vagina will disclose a mass occupying the hollow of the sacrum. If a catheter is inserted and pressure brought to bear upon the tumor mass, the residual urine will be evacuated, so that the mass will disappear. Viewed through the cystoscope the

opening into the pouch will show as a dark hole, sometimes large enough to permit the cystoscope to be passed into it. Fischer mentions that if the opening is small it may be mistaken for a ureteral orifice, so as to suggest the presence of a supernumerary ureter. He cites the device of Tilden Brown and Osgood who introduced into the questionable opening a catheter armed with a stylet and had an roentgen-ray picture taken. The plate showed the catheter coiled up in a cavity, thus demonstrating with certainty that they had to deal with a diverticulum.[23] The ingenious device of Prof. Eugen Josef of Berlin is helpful in visualizing a diverticulum. He has perfected a long catheter-like instrument with a small light on its end. This introduced into a diverticulum will transilluminate it so that the examiner gets a very accurate idea of the size of the cavity.

The method of Herbst is also helpful in determining whether a diverticulum is retentive or not. A roentgenogram is taken with bladder and diverticulum filled. Then the opaque liquid is removed from the bladder which is then filled with air. The contrast is brought out by making another roentgen-ray exposure.

Treatment.—The treatment is surgical, except in a few cases. The condition may be benefited by drawing off the residual urine and thorough lavage of the bladder with weak antiseptic solutions. The patient should be urged to drink fluids freely, especially some carefully selected table water, and drugs such as urotropin or benzoic acid may be orally administered.

HUNNER'S ULCER.

Ten years ago Guy L. Hunner of Baltimore called the attention of urologists to "a rare type of bladder ulcer" which has since been designated by his name. This lesion is described by Hunner[37] as a chronic inflammation of all coats of the bladder wall, likely to be very wide-spread before the condition is recognized, yet in spite of this wide-spread lesion there is remarkably little to be found by cystoscopy and this is one reason that many of these patients have suffered fifteen years or more, and have traveled from clinic to clinic in an effort to find relief.

Cystoscopic Appearance.—The patient should be placed in a proper examining position and be well enough relaxed to enable the operator to scan every portion of the bladder mucosa, including the anterior wall back of the symphysis.

Often all that can be perceived will be a small abrasion upon the surface of the mucosa which bleeds very easily if touched, or may be bleeding when it first comes into the range of vision. This is most commonly located in the vertex or free portion of the bladder, upon the anterior superior wall, a section of the mucosa frequently overlooked in the routine cystoscopic examination, which in large measure accounts for the many occasions upon which this lesion goes unrecog-

nized. The actual abrasions of the mucosa may be single or multiple. If multiple, they may be in a small group, or they may be widely separated, one ulcer being found in the vertex, perhaps close behind the symphysis on the anterior wall, and another near the base on the posterior wall. The ulcers are always of small size, not more than 2 to 5 mm. in diameter, and have a superficial appearance, but as soon as the spot is touched it will be found to be exquisitely sensitive, and a preliminary bimanual examination of the bladder will often suggest the location of the ulcer because of this tenderness. On cystoscopy one's attention is not infrequently first arrested by a glazed dead-white appearance of a portion of the bladder mucosa. In such an infiltrated area the vessels may have a broken or "choppy" appearance, only short segments of vessels appearing on the extra pale surface. One may see a dead-white scar area with a small congested area in the immediate neighborhood; and while one is examining this area, or after one has touched it, the congestion becomes marked and may even begin to ooze blood. Sometimes during the cystoscopy an area of edema appears, the mucosa taking on a deep red, congested appearance, and being raised above the general mucosa level. This area of edema may occur immediately about the ulcer area, or it may appear on the portion of the wall at some distance from the ulcer. It may be absent at several consecutive examinations and then appear at a subsequent examination. It is particularly likely to be seen if the patient is in the midst of an unusually bad period of bladder symptoms with strangury. This is one of the characteristics which have led certain investigators to term the lesion "elusive" ulcer.

Pathology.—Excised specimens give a picture of chronic inflammation involving all the bladder coats, which show a wide extent of edematous thickening. At the immediate site of the ulcer itself there is a loss of epithelium, with granulation of the submucosal tissue. Some of the specimens have shown an abrupt ending of the epithelial layer at the edge of an area that is evidently undergoing healing, and here the mucosal layer is less richly supplied with capillaries, and is much like the mucosa beneath the epithelial covering, showing a preponderance of connective tissue and infiltration of small round cells and leukocytes. The histological findings have an especial interest in that they show that the mucosa is extensively denuded of its epithelial coat, although the cystocope has revealed such a comparatively insignificant lesion.

Etiology.—The etiology of this vesical lesion has so far remained obscure. All of Hunner's cases occurred in women, but this is only because his observations are exclusively confined to that sex. His associates quickly found the same conditions in men, after the characteristics of the condition had been pointed out, and more recent reports[45] indicate that sex has no bearing upon the production of the lesion. Neither does it seem to be dependent upon a previous infection of the urine, for the urine is practically always sterile. Some

of the patients have dated their "bladder trouble" back to some attack of infectious disease in childhood, and a number of the cases have a history of tonsillitis, but there is as yet, insufficient data on which to ground a theory of focal infection as the causal factor. Hunner noted that in many instances there was a coincident history of urethral inflammation and thought it possible that the bladder ulceration and the urethral inflammation might be of a common origin, or again that hypertrophy and extreme sensitiveness of the sphincter region might be caused by the frequency and straining incident to the urethral condition.

Symptoms.—Pain is always the most obtrusive symptom, with other evidences of the existence of cystitis either present or veiled. There may be frequency, both noctural and diurnal, and hematuria, most commonly slight and intermittent, is a fairly constant feature, though in Hunner's earlier reports he states that very few of his patients gave any history of hematuria. Little information can be obtained from examination of the urine; it is likely to be macroscopically clear, and even when centrifuged, only a few leukocytes and erythrocytes will be found. These may be lacking at the next examination, for the ulcer frequently heals over temporarily, and under such conditions will give no indication of its existence which can be detected by urinalysis.

Pain must be therefore, the clinician's chief guide to the actual nature of the bladder lesion. This is frequently excruciating, described as a sensation of stabbing or as if there were a jagged sharp stick in the bladder. Frequently the pain will be referred to the rectum or to the hip, less often to the perineum. Any undue movement or jarring will cause the greatest anguish, and the increased peristalsis following eating often gives rise to an increase in the victim's sufferings, so that he will be convinced that he is suffering from a cancer of the rectal region. When one considers the literature of the past, with its many references to "neuroses of the bladder," and recollects in his own experience, the diagnoses of "nerves" which have finally been given when repeated examination of the urinary tract has failed to reveal any evident cause for this excruciating pain, it is easily realized that this type of bladder lesion may be far more prevalent than we have heretofore had any reason to believe.

Diagnosis.—The diagnosis must be founded on the cystoscopic appearance, the urinary findings, if any, and particularly the patient's own story. Hunner says that he has learned from experience to suspect the presence of this lesion when he is consulted about any patient who has suffered for years with symptoms chiefly referred to the bladder, but varied enough in character to have led to a number of operations without relief of the symptoms. If such an outline of trouble ends with the statement that "there has never been anything of importance in the urinary findings, only at times a few leukocytes or red cells," his suspicion is changed to a practical certainty.

Treatment. - Treatment has proved satisfactory only in those cases which have been submitted to surgical excision of the diseased area. Palliative measures have served to allay the pain and other most obtrusive symptoms, and where operation is for any reason inadvisable, may serve to give a relative amount of comfort, but permanent healing has not, so far as we know at present, spontaneously taken place.

LEUKOPLAKIA OF THE BLADDER.

Leukoplakia of the bladder is a condition so rare as to be considered by most text-book writers as not meriting description. What scanty literature there is to be found upon it is, for the most part contained in foreign medical publications, mostly periodicals, which are inaccessible to the average American physician. So far as we are aware, no more than 5 or 6 cases have ever been reported in this country. The whole subject was very painstakingly reviewed by Kretschmer five years ago, so that it is to him that American urologists are indebted for most of the knowledge on this subject which is now at our disposal.[45] We have found but 1 additional case published since this article appeared,[68] making a total of 45 in all .

Cystoscopic Appearance.—Vesical leukoplakia has an appearance so characteristic, that to the cystoscopist who has once seen it, its recognition presents no difficulty. The bladder mucosa will show dull white or grayish plaques of irregular shape, which may be very small and few in number, or may form a practically complete covering of the entire mucous lining of the bladder. The mucous surface which is visible about the plaques is usually inflamed or ulcerated, and a very striking feature is the absence of bloodvessels. In Kretschmer's own case the entire vesical mucous membrane was white, dull and without luster, and no bloodvessels were seen in the area of the leukoplakia. Valentine's patient showed a rather intensely reddened trigone in the center of which was seen a snow-white patch of flocculent membrane, irregular in outline with sharply-defined borders about the size of a twenty-five-cent piece.

Etiology.—As is the case with so many vesical conditions, the cause of leukoplakia is unknown. None of the numerous theories which have been advanced are sufficiently elastic to cover all the reported instances, few as they are. In some of the cases there have been calculi in the bladder, but in many this association was not present, and of course, we are aware that thousands of cases of stone in the bladder never show leukoplakia. Some investigators have believed it a congenital condition, but this can hardly be true in all cases, although in Leber's case the patient was but four months old, which, while we cannot generalize from a single instance, would certainly point toward the possibility of such an origin. Almost all of Hallé's subjects had an old bladder inflammation, a stricture which had induced retention, uretero-pyelitis or cystitis due to gonorrhea, or prostatic hypertrophy,

all conditions which might induce chronic inflammation, a fact which led this author to believe that the transformation of the vesical mucosa was due to the effects of chronic inflammation of some kind, thus producing changes in the epithelium. Venereal disease has also been accused, as in many of the cases a history of gonorrhea or of syphilis could be elicited. A careful analysis of the available evidence however, does not bear out this view, for the venereal history was lacking in too many instances to make the hypothesis of any great value.

Symptoms.—Aside from the cystoscopic picture, the symptoms are not markedly characteristic. In most of the cases "bladder trouble" dated back for many years. In Czerny's case there had been no symptoms whatever; the patient, a boy, aged twenty years, fell from a roof, and after this accident had difficulty in voiding. A diagnosis of vesical diverticulum was made and suprapubic cystotomy revealed a diverticulum, the lining of which had an epidermis-like appearance and consisted of many edematous sloughs and pavement epithelial cells. The common complaints are of painful urination, which is usually frequent and urgent, and many other urinary symptoms which are very likely to be induced, not by the leukoplakia, but by coexistent pathological conditions. The findings in the urine are the most reliable indications. Commonly there will be a history of passing "membranes," often with attendant renal colic. It is probable that those patients who relate passing "sand and gravel" may have actually seen small masses of epithelial cells which they mistook for calculus deposits. Resort to cystoscopy will usually clear up the diagnostic difficulties.

Treatment.—Treatment is not often satisfactory. Lavage and other palliative measures are sometimes of benefit, but surgery which is sufficiently radical to remove coincident pathological conditions will usually offer the best end-results.

ENURESIS: INCONTINENCE.

The terms enuresis and incontinence are used interchangeably by many writers, but we feel that there is a distinction between the two conditions which should be emphasized. By *enuresis* is most commonly indicated nocturnal incontinence of children, or at least an apparent inability to prevent the evacuation of the bladder, which is dependent upon habit or mental condition, rather than the physical state. True *incontinence*, on the other hand, is seen more frequently in adults, than in children who are not the subjects of an anomaly such as ectopia vesicæ, and is definitely dependent upon some physical abnormality or pathological state. While enuresis in the great majority of cases, can be relieved by the establishment of proper habits and environment, incontinence usually requires resort to surgery, and because of its more serious character, is much less favorable in its ultimate prognosis.

Enuresis of Childhood. The mechanism of urination is almost completely under the will of the adult of normal physique and mentality. When the bladder has gradually been distended by the accumulation of urine ejected into its cavity from the ureteral orifices, a rhythmic contraction of the vesical walls is set up, and gradually increases in intensity until a few drops of urine are forced out into the posterior portion of the urethra. The presence of urine in this area induces a sensory stimulus which passes to the nerve center in the lumbo-sacral cord, and by this means afferent impulses are set up which bring about vigorous contractions of the vesical wall and relaxation of the sphincter. In infants this urinary reflex can be inaugurated by almost any irritative influence which is brought to bear upon the pelvic organs, so that involuntary urination results. Usually, however, by the end of the first year of life the child has begun to acquire voluntary control of the bladder function, at least during the day-time. By the end of the second year most children have gained complete urinary control, and any child who still has involuntary urination when he has reached three years of age, may be properly said to suffer from enuresis. Enuresis in children is therefore, not properly a disease, but simply the persistence of an infantile condition or habit.[22]

Etiology.—The cause of this persistence can, in many cases, never be satisfactorily determined. Grover attributes it to neuro-muscular fatigue.[31] He observed a large number of children who presented this condition and noted that they were all exceedingly active and nervous, and the majority were not given sufficient rest to counteract the strains of a long and active day. Most bed-wetters sleep very soundly, so it is often difficult to wake them to urinate. Emerson failed to find any marked incidence of the various physical abnormalities which are generally believed to be associated with enuresis, such as adherent prepuce or clitoris, mental retardation, carious teeth or malnutrition, but he did observe naso-pharyngeal obstruction with such frequency in several large series of cases, as to make it appear more than an accidental association. Subacute inflammation in the urinary tract has often been searched for, and postulated as a cause of enuresis, but it is more than likely that these when found, are merely another indication that a mild cystitis or pyelitis is a secondary condition, and that the patient being in a "run down" condition, such as is often the case with an over-worked and unduly stimulated schoolchild, there is a flaring-up of these previously more or less quiescent conditions. Grover thinks it probable that the general bodily fatigue may be responsible for both the continuance of the inflammation, and the prolongation of the enuresis.

Treatment.—The most successful handling of these cases of enuresis in children has come through mental training and the establishment of proper habits. Punishment practically never brings any good results, but the offer of rewards may often serve to arouse the child's ambition so as to overcome the unconscious reflex. More productive of per-

manent results however, is the establishment of proper urinary habits, what Newlin[54] has described as "the simple procedure of anticipating the involuntary by a voluntary emptying of the bladder." The child should be sent to the toilet at frequent intervals during the day and wakened during the night *before* the accustomed time of bed-wetting, as in practically all cases it will be found that the involunatry evacuations of the bladder take place each night at approximately the same time. The intervals between these arbitrary times for urination can be gradually lengthened as the mechanism of micturition comes gradually more under control of the will. This training, in combination with careful attention to diet and the abolition of exciting factors in the child's mental and physical life, will serve to correct about four out of five of the cases of enuresis.

Treatment by Irritation.—There remains, however, a small proportion of children, upon whom no amount of training has any effect, yet in whom no organic lesion can be discovered. Two methods of dealing with these unresponsive cases have been suggested. The habit of self-control may sometimes be established by using a bougie-à-boule, introduced into the urethra under aseptic conditions and passed as far as the bladder without pain to the child. It is then withdrawn through the sphincter and passed back and forth several times, enough to irritate the surface so as to cause a considerable discomfort the next few times that urine passes over this area. The fact of this slight pain in the sphincter region and the posterior urethra serves to fix the child's attention, intensifying the sensory impulses enough to aid in establishing proper habits of bladder evacuation.

Cerebrospinal injection has been resorted to in extreme cases, the procedure being carried out as for lumbar puncture for other purposes. Physiological sodium chloride solution thus injected will produce such a stimulation of the whole mechanism of consciousness that habit will thereafter hold it under voluntary control. Under cocaine analgesia 10 cc. of spinal fluid are withdrawn, and 12 cc. of freshly prepared physiological salt solution injected in its place. The child should then be placed in bed for at least six hours, as there is apt to be considerable reaction unless the salt solution has been prepared with the greatest care, the water freshly distilled and filtered. This method should only be used in the most extreme cases, or those complicated by mental deficiency. The employment of lumbar puncture is never a matter to be lightly undertaken, and it is only consideration of the great handicap imposed upon an adult by inability to control urination which renders the use of such extreme measures justified.

Etiology of Incontinence in Adults.—Aside from the cases of infantile enuresis which have been permitted to persist into adult life, there is a distinct class of cases where the inability to control the urinary reflex is due to other causes. Postoperative incontinence need hardly be considered, for under these circumstances the control of the condition

is one of the problems connected with the surgical sequelæ which must be adjusted along with other postoperative irregularities.

Relaxed vesical sphincter is a not infrequent cause of incontinence in women who have borne children, especially those who have undergone difficult instrumental labors. This incontinence may appear immediately after delivery or somewhat later in the puerperium, and occasionally several years will elapse before urinary control is lost. Furniss[27] states that most of his cases occurred in women over thirty-five years of age, and that he has occasionally found this form of incontinence in nulliparous women at about the time of the menopause, or somewhat later. When seen in women who have neither borne children nor undergone an abdominal operation, he believes it must be attributed to nerve disturbance or progressive muscular weakness.

Treatment.—Silver nitrate applications, more especially in the coexistence of inflammation of the urethra or the trigone, have sometimes been all that was necessary to correct the milder degrees of incontinence. Support by a pessary or tampon may be sufficient to prevent leakage, and stimulation by galvanism has been successful in the hands of some practitioners. Furniss lists a number of operative measures which have been recommended: Twisting of the urethra through 180 degrees after dissecting it free (Gersuny); advancement of the urethra, so that it is stretched and angulated under the symphysis pubis (Dudley); injection of paraffin around the sphincter; dissection of the pyramidalis muscles, passing them down under the symphysis and around the urethra (Stoeckel); the same procedure using the inner edges of the levator ani; shortening the posterior portion of the sphincter after suprapubic cystotomy (Young). Furniss himself exposes the anterior vaginal wall by posterior retraction, dissects the vaginal wall away from the bladder through an incision in the mid-line just back of the urethra, and with a Pezzer catheter in the bladder, and one finger against the anterior vaginal wall, locates the sphincter as the structure just anterior to the mushroom part of the catheter where it meets resistance on withdrawal. The sphincter is then folded against the floor of the urethra and narrowed from side to side by means of two tiers of mattress stitches, with careful avoidance of undue tension, which would induce sloughing. If there is a tendency to urethral prolapse, the urethra should also be brought forward when the sphincter is narrowed.

Hypertonic Bladder.—Hypertonic bladder is the designation applied some years ago by Brahdy[9] to a condition where there is a very urgent desire to urinate when the bladder contains not more than 150 cc. of urine, and involuntary urination takes place if the bladder content is not immediately evacuated. In the reported cases there was lumbar pain, tenderness over the lumbar vertebræ in most instances, and in some of the patients, spasm of the abdominal and leg muscles on filling the bladder preparatory to cystoscopy.

Trabeculated Bladder.—Trabeculated bladder appears to be a fairly constant finding in these cases of incontinence. Pelzman[56] has described trabeculation which he observed posterior to the interureteric ridge and postero-lateral wall in certain cases of "enuresis" which he cystoscoped at a military encampment during the World War. Both the observers mentioned elicited a history of difficulty of urinary control in other members of the families of the subjects examined, and are inclined to believe that the condition is congenital, though not in the sense usually applied.

Treatment.—Treatment has not proved very satisfactory. Brahdy attempted to dilate the bladder by the daily injection of from 400 to 600 cc. of boric acid solution. He found that in some of his patients this increased the bladder capacity to nearly double the amount it was formerly able to hold without inducing the urinary reflex, but the urgency remained as great as before.

SURGERY OF THE BLADDER.

All things considered, it is probably more difficult to operate upon the urinary bladder than upon any other abdominal or pelvic viscus. Its well-protected location under the bony pelvis makes it relatively inaccessible, and the fact that it has less protection from the peritoneum than its neighboring organs, being largely surrounded by an envelope of fat, makes it much more liable to infection. Yet these marked disadvantages have been overcome in a truly remarkable manner by modern practitioners of surgery, and there is no branch of this art which can point to a more brilliant array of happy results than are told in the annals of vesical intervention. The very difficulties to be surmounted have made the results all the more spectacular, and the introduction of fulguration, and later of radiotherapy for the treatment of a number of bladder lesions heretofore considered confined to the surgeon's province, has in no wise diminished the prestige of those who have been conspicuously successful in the technic of vesical surgery.

Cystotomy.—*Cystotomy for drainage and stone* has already been touched upon in the sections upon prostatectomy (page 438) and vesical calculus (page 496). This procedure is now easily carried out under procaine infiltration anesthesia. The bladder is washed out and distended with sterile solution of the preferred antiseptic, the patient placed in the Trendelenburg position with the hips raised high. When the body is placed at this angle most of the content of the abdomen will gravitate back away from the pelvis, while the bladder, weighted by its fluid content, will also fall back, and by so doing cause a separation between the pubes and the peritoneal fold, leaving a space from a $\frac{1}{2}$ to 2 inches, according to the size of the individual undergoing operation. Through a median incision just above the pubes, the pyramidales and recti are dissected down to the anterior

peritoneal fold, the fascia propria being cut across close to the bone. When the fascia and peritoneum have been drawn upward, the anterior wall of the bladder will come in sight, and the vessels upon its surface will be sufficiently visible to permit the surgeon to incise the vesical wall without interfering with them. A finger inserted through this opening can now explore the bladder for the detection of foreign bodies, stones or pathological conditions which require this procedure for

FIG. 149.—Local infiltration of the skin with procaine, 0.5 per cent, administered as a preliminary to suprapubic cystotomy. The old way consisted in anesthetizing each layer before incising it. This has been displaced at the Brady Foundation for Urology of the New York Hospital by the bloc method of anesthesia.

their investigation. This can be done while the escape of its fluid contents enlarges the incision in the bladder wall.

Removal of calculi is usually accomplished by the introduction of forceps or a lithotomy scoop designed for this purpose. The possibility of more stones being concealed in a diverticulum (page 501) must always be kept in mind. In old persons, as Judd[41] has aptly said, the risk of removing stone is not due to the operation itself,

but to poor general resistance, and the danger from the infection which is almost certain to be present, for when there is a stone lodged in the bladder, the renal function is almost sure to be considerably reduced.

Drainage is necessary in any suprapubic cystotomy, whether or not this is the primary object in opening the bladder. The procedure does not differ in any great degree, and the preoperative precautions and after-care are practically identical. The routine treatment of prostatic patients who have undergone this operation has already been discussed (page 438).

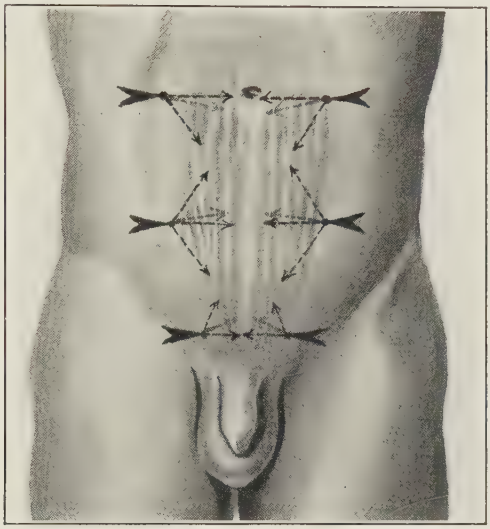


FIG. 150.—Bloc method of anesthesia. Procaine 0.5 per cent is injected above and below the rectus muscles on each side in a fan-shaped area, usually starting at three points; one opposite the umbilicus, one above the pubic spine, and the third half-way between. In addition, the prevesical space is thoroughly injected with the same solution previously used but without adrenalin.

Cystectomy.—Cystectomy may be either partial or total. The second procedure has been successfully carried out in a few instances, but is of course, to be looked upon only as a desperate "last resort." The treatment of bladder malignancy, for which this procedure formerly offered at times the only hope of cure, has been so extended by the employment of radium and the high-frequency current, that complete extirpation of the bladder is not likely to be extensively practiced at any time in the future, despite the fact that we have now attained such high success in the transplantation of the ureters and the establishment of urinary control by a return to the conditions found in birds and a few of the lower mammals.

Resection of the Bladder.—Resection of the bladder still has a wide usefulness in a number of conditions, and holds its own as the best method of handling malignant tumors, although the rapid

advances in the application of radiotherapy seem likely to cause its displacement before much time has elapsed. Fulguration is not a suitable treatment for malignant growths, its great usefulness lies in the extirpation of benign papillomata and similar neoplasms. The use of the high-frequency current may however, be very profitably combined with surgery under certain conditions, as has been demonstrated by one of the ablest of American urological surgeons.[4]

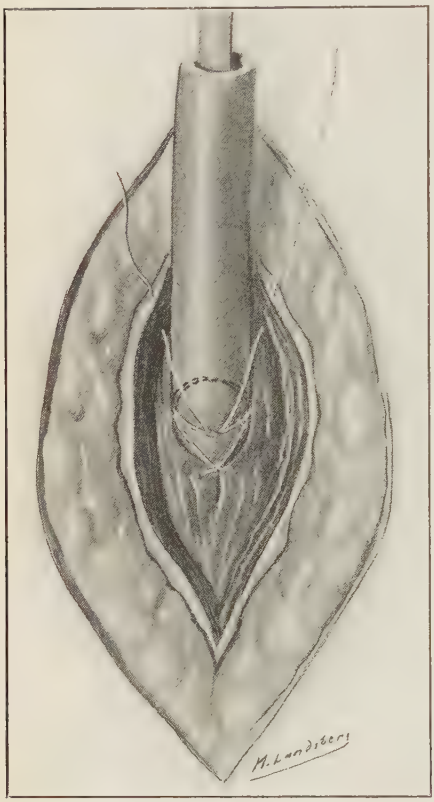


Fig. 151

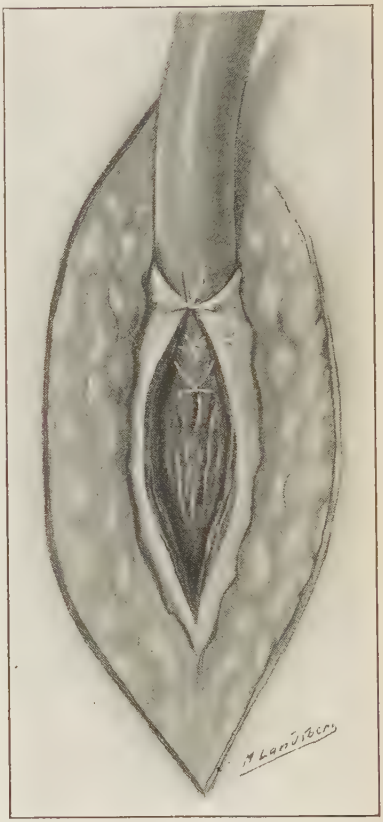


Fig. 152

Fig. 151.—After the bladder has been opened and the necessary intravesical surgery performed, the double suction tube is sutured to the highest point in the bladder wound and firmly fixed by catgut tied around it. The free ends of the catgut are then brought through the fascia near the top of the incision, as shown above.

Fig. 152.—The catgut stitch is tied across in front of the tube, fixing it in such a manner that its course is oblique as it passes through the body wall.

Beer's Procedure.—Beer's procedure is described by its originator as follows:

(1) The bladder is gently irrigated and then emptied, so that when it is opened the wound is not flooded with fluid containing tumor cells.

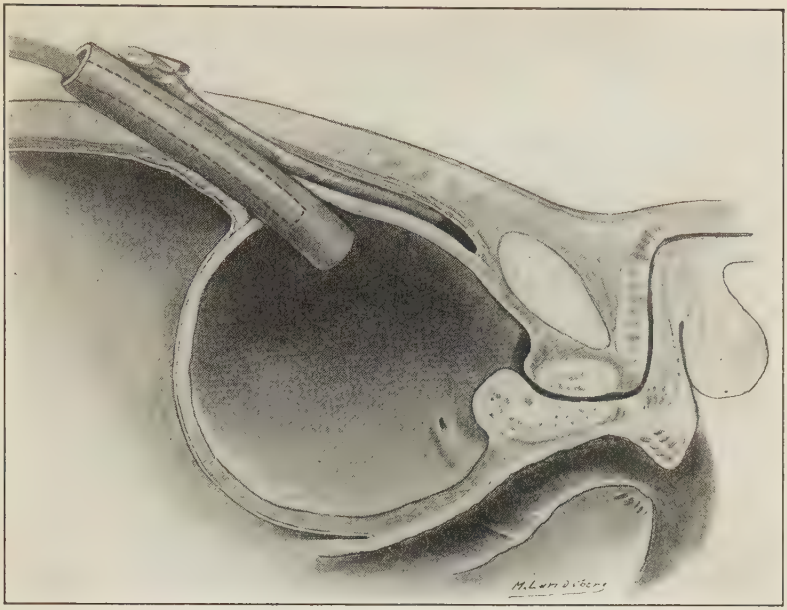


FIG. 153.—This sagittal view shows the double-suction tube fixed at the top of the wound in the bladder, passing obliquely through the abdominal wall, with a cigarette drain inserted into the space of Retzius. This position prevents the tube from impinging on the opposite wall of the bladder. Its oblique course through the body wall makes for rapid healing when the obstruction is removed and the tube taken out. The pressure of the abdominal contents in itself will aid its closure. The patient is kept dry and clean by attaching the small inner tube to a vacuum bottle. Any fluid arising in the outer tube will be sucked away by the inner. The air column between the two tubes prevents the bladder wall from being drawn up into the tube.

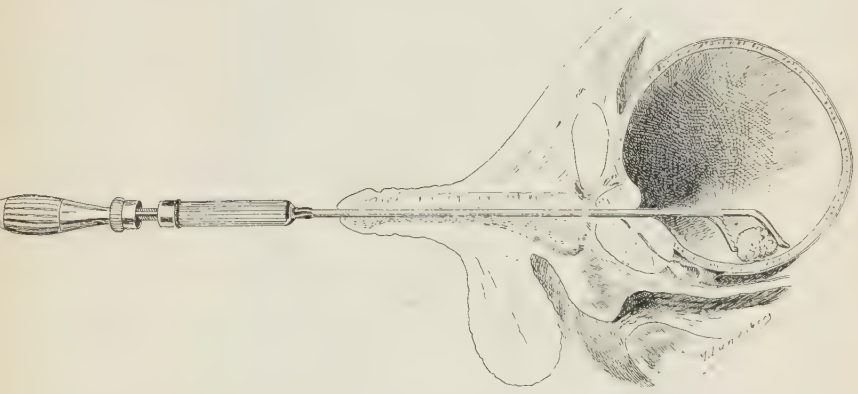


FIG. 154.—The Lithotrite is here represented in position grapsing a stone for crushing. Small stones are best removed with the instrument of Lowsley. Large stones are unsuitable for crushing and should be removed by a suprapubic cystotomy. Only medium-sized stones should be crushed by means of a lithotrite. By using sacral and parasacral anesthesia and the lithotrite, this operation in skilful hands is very satisfactory and quite economical for the patient, particularly as regards the factor of time in the hospital.

FIG. 155.—The fragments are removed by the application of the suction bulb and fragment collector to the large caliber steel tube which is introduced into the bladder.

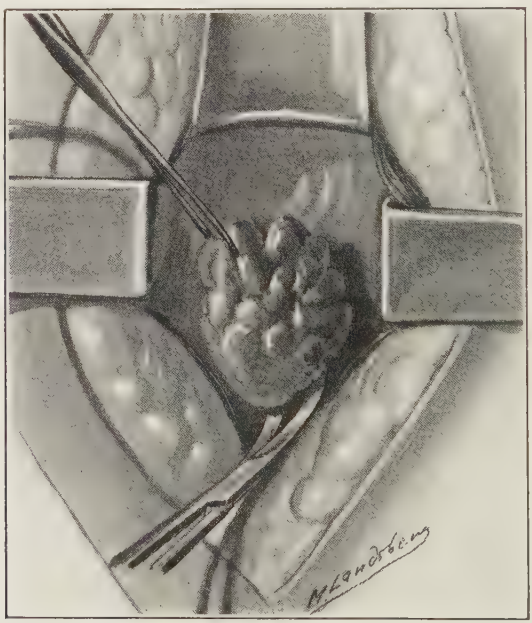


FIG. 156.—Tumors of moderate or large size may be excised with the cautery or if removed with scissors, the base is cauterized. This procedure is advisable in non-malignant tumors which have not responded to fulguration.

(2) The patient is placed in a moderate Trendelenburg position and a wide vertical suprapubic incision is made. (3) As the bladder is exposed extraperitoneally, it is freed from its bed of fat and peritoneum by blunt dissection to either side of the urachus, which is double-clamped and cut between. The clamp in the bladder end of the urachus is used to draw the bladder forward and toward the symphysis as the peritoneum is sponged off its posterior surface. This may be opened accidentally and will allow of palpation of the extent of infiltration, etc., of the walls of the bladder. (4) After the bladder has been well freed down to the trigone in this manner, and delivered

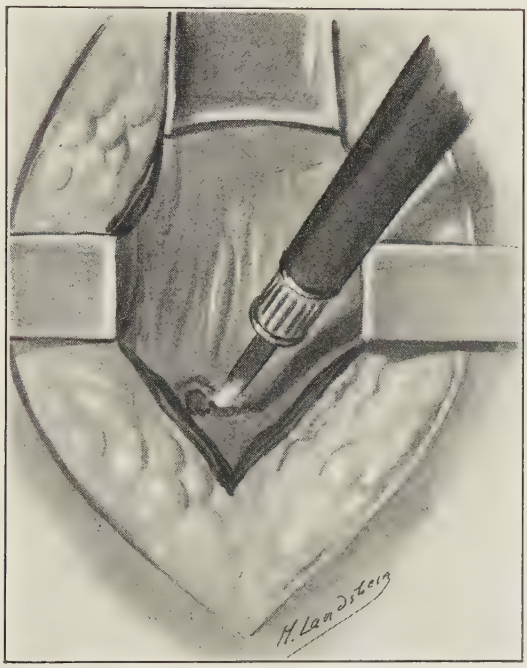


FIG. 157.—The base of the tumor is shown being subjected to cauterization with the actual cautery.

well out of the abdomen, the perivesical space is carefully packed off with several layers of gauze abdominal pads which protect the perivesical space and the incision in the parietes. (5). Then, depending upon the position of the growth or growths, the bladder is incised either through its anterior, its posterior, or its lateral walls, enlarging the incision so that any fluid which may chance to remain in the vesical cavity may be sponged up, though sponging within the cavity should be reduced to the least possible minimum. As the incision is enlarged the papillary growth will be exposed to view, and should be immediately cauterized *in situ* with the electric cautery (hook) or with the Paquelin

(hooked point). In cases of multiple growths, each growth is separately burnt, and every suspicious spot is treated similarly. A too extensive cauterization is preferable to a too superficial one. If the papillary growth is so large that it cannot be treated in this ideal manner, it may be seized with a blunt-ring clamp and delivered piecemeal until the pedicle is reached, when a Carmalt-curved clamp is placed across this and the cautery slipped between the clamp and the bladder wall. If the bladder wall is infiltrated, a wide cautery resection of this area is carried out. If the ureter is involved in the infiltrated area it is left attached until this area is resected, and then cut away from the resected portion at a distance from the growth. Thereafter it is implanted in a healthy part of the bladder just before the bladder wounds are sutured.

Though an automatic retractor in a parietal wound is essential and very helpful, when we have such a deep cavity to expose, it is better to use retractors of different sizes and lengths, so as to go over all the surfaces of the bladder readily, while at the same time none are covered more than momentarily. The use of clamps with teeth, such as the Kocher, should be avoided; as the bladder incision is being made toothless clamps should be applied to hold the bladder out from the body.

The incision in the bladder wall is seared all around, removing the clamps as they are encountered, so that no part of the wound may serve as a place of implantation for tumor cells. The table is now lowered and the entire wound filled with alcohol, the bladder being allowed to slip back into its bed, so that the vesical cavity, as well as the gauze used to protect the surrounding tissue may be exposed to the sterilizing effects of the alcohol. Fresh gauze is then substituted, the bladder sponged dry and the incision closed with a suprapubic drain. If necessary, the ureter is implanted in its new location. The charred edges of the incision are closed with plain catgut, with a supporting layer of chromic gut stitches over the first row. The wall is closed in layers with rubber or gauze drainage on both sides the tube being left within the cavity.

Squier's Technic.—*Resection of Bladder for Tumor.*[63]—From a point 1 inch above and to the left of the umbilicus, an incision is carried downward to a point in the median line 2 inches above the symphysis. The peritoneal covering is opened by dividing the sheath of the rectus along the entire extent of this incision. With the patient in the Trendelenburg position, the intestines are gently pushed to the upper part of the abdominal cavity, and the pelvic cavity thereafter walled off with gauze.

The abdominal incision is then lengthened downward through skin and fascia and the pyramidalis muscle divided at the symphysis, exposing the prevesical space. Upward traction upon the peritoneum and urachus by means of a Bartlett's intestinal forceps grasping the lower angle of the peritoneal incision, brings the obliterated hypogastric arteries into view; whereupon the left artery is grasped with

a forceps and traction made upward and to the right. The left vas deferens is exposed by blunt dissection, made taut by gentle traction and by following the course thus indicated, blunt dissection next uncovers the pelvic ureter "as it bends inward above the fascia of the pelvic floor to enter the bladder." The right ureter is exposed in a similar manner.

The urachus is divided close to the bladder and from the two points of lateral dissection the peritoneum is stripped off the fundal surface of the bladder, deep into the recto-vesical space, pushing the peritoneal cul-de-sac of Douglas upward and backward. The superior poles of the seminal vesicles are exposed by downward traction upon the bladder, exposing the entire fundus of the bladder and the upper posterior surface of the trigone by the same maneuver; the ureters also, are under direct vision, although the pubo-vesical attachments of the bladder have not been disturbed. Hot wet pads control any venous oozing. By attaching the denuded lamella of the peritoneum to the upper end of the abdominal incision, all subsequent procedures are carried out extraperitoneally.

Grasping the bladder high up on the posterior surface, a longitudinal incision about 1 inch long is made in the wall, and when inspection has determined the site of the neoplasm, the incision is extended to meet the needs of the case in hand and give sufficient exposure. The growth should be excised *en masse* with a wide margin of healthy tissue comprising the entire thickness of the bladder wall. If the ureter is included in the excised area, it is divided between two ligatures and its distal portion extirpated along with the tumor. The cut edges of the bladder wall are now partially drawn together, a stab-wound made at a point approximating the normal ureteral opening, and the proximal portion of the divided ureter is drawn through the stab-wound and anchored to the vesical wall, a length of $\frac{1}{2}$ to $\frac{3}{4}$-inch of the ureter being allowed to protrude into the bladder. This ureteral stump is then bisected into two flaps which are turned back and anchored. The remainder of the bladder defect is now sutured, and provision for drainage made by a stab-wound at the point which corresponds to the highest point in the bladder after the operation is completed. Through this a No. 26-French catheter is passed and sutured *in situ*.

If the peritoneum has been invaded by the neoplasm, it must be resected and sutured, particular care being taken to prevent a peritoneal suture line being superimposed upon a bladder suture line. Otherwise the incision in the peritoneum is closed, the peritoneum itself replaced, and the abdomen closed after a cigarette drain has been placed in each lateral space.

Simple Resection.—Simple resection is now followed in the practice of nearly all operators by cauterization of all the operative wounds. The disposal of the ureter is usually a matter of prime importance in any extensive resection of the bladder wall, and this will be discussed

further on, in connection with ureteral surgery (page 578). At the Mayo Clinic the resection usually involves the removal of at least a quarter of the bladder. Most of these operations are done with the knife, but the cutting cautery is also used, with about the same final outcome. Judd tells us that it has proved a matter of surprise to them that in those tumors which they deemed not suitable for operation, but to which they applied the Percy cautery, the patient has in some cases remained well for as long a period as six years.[41]

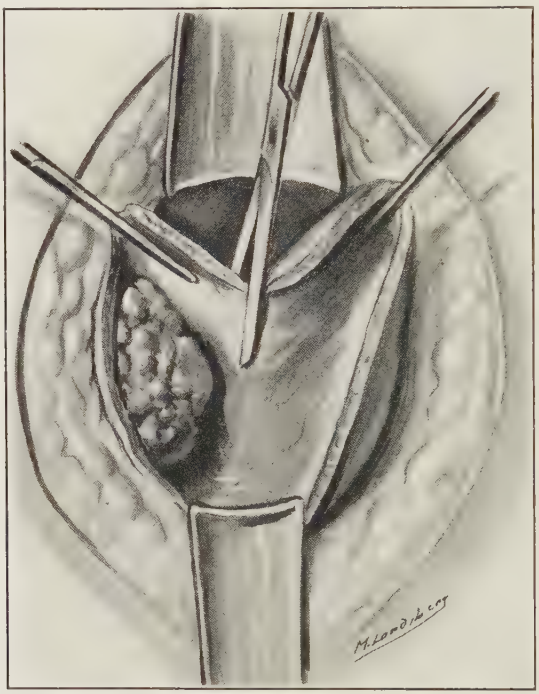


FIG. 158.—The vesical wall immediately behind the malignant growth having been mobilized and no more of it than necessary so treated, the wall of the viscus is then incised and the tumor, with a wide cuff of normal mucosa surrounding it, removed. Great care must be taken not to handle the growth, as pressure may disseminate the cancer cells. The surrounding tissues are well walled off to prevent the possibility of implants.

The authors make it a practice to separate only that part of the bladder wall involved, in resecting a portion for carcinoma of the bladder. It is felt that wide mobilization of the bladder will disturb the circulatory and lymphatic apparatus to such an extent that the viscus will be partly devitalized. The results obtained by this method justify its continuance.

Resection for Ulcer.—Resection for ulcer should be kept an extraperitoneal operation if this is at all possible. Hunner says that this can be accomplished in those cases where the disease is limited to the

vertex and anterior wall, and it is occasionally possible to separate the involved peritoneum when a portion of the bladder covered by this structure is involved in the ulcerative process. More often however, it will be impossible to avoid breaking through either the

FIG. 159.—In this case the growth included the ureteral orifice which was removed, the ureter being severed about 1 inch above the bladder wall. It was then brought obliquely through the vesical wall as shown in insert *a*, split as shown in insert *b*, and sutured in accordance with the plan seen in insert *c*. The first case done by this method by the authors occurred in July, 1917. That patient is alive and actively engaged with his busy brokerage business. He has been recently cystoscoped and shows no recurrence. Since that time 7 similar cases have been operated upon, of whom 4 are alive. One of these has a recurrence and is being treated with radium.

peritoneal covering or the bladder wall itself. Experience has taught that the best method of separating the peritoneum is first to brush back the vertex portion as far as it will go with ease; then, instead of persisting in trying to carry this separation further down the posterior

wall from the vertex, one should next free the lateral walls and attempt to get down near the ureter region on both sides. From near the base in the lateral or ureter regions one can work toward the mid-line about the base of the bladder; and after separating the peritoneum in the utero-vesical region, one can finally come forward on the posterior wall until the entire peritoneum, except the urachus portion, is freed. The freeing of the urachus portion can be done with less danger of entering the peritoneum if done as the final stage in the separation than if undertaken as the first step. If it is found at any point that the peritoneum cannot be separated from the bladder wall, it is best to continue the separation at other points until all the peritoneum that will separate easily is free. Then one enters the peritoneum with a free opening and packs off the peritoneal contents with an abundance of gauze pads soaked in hot salt solution, before entering the bladder.[37]

The cystoscope should always be used in determining where the bladder should be opened, so that we may avoid cutting down upon the inflammatory area. For example, if the area of inflammation is to the right of the mid-line, the incision should be on the mid-line, or a little to the left of it. Should the inflammatory area be widespread and extend to within a short distance of the sphincter, a good deal of care must be exercised to incise as near the urethra as possible without in any way traumatizing the sphincter urethræ itself. Attention should be paid to clamping and tying off the vessels as they are reached, as otherwise they are likely to retract into the wall, so that bleeding will be temporarily suspended, only to recommence later, often with the gravest results. Hunner mentions particularly that on opening the bladder the edema which has arisen since the preliminary cystoscopy may have caused so much swelling of the mucosa as to completely hide the two or three small ulcers that had been visible through the cystoscope, but in many cases this preliminary trauma will cause so much bleeding from the ulcers that their whereabouts will be easily ascertained. He advises that sponging be avoided as much as possible, a suction apparatus being provided to keep the operative field clear.

Twenty-day formaldehyde catgut, put in with a running lock-stitch is used to suture the edges after the diseased area has been excised. A retention catheter should be carried through and sutured to the bladder wall, and two cigarette drains also carried down to the bladder wall, the external wound being closed about all three. The drains are removed at the end of the second day and irrigations given through the catheter, employing for this purpose a 1 to 10,000 silver nitrate solution, gradually strengthened as convalescence progresses. With the patient on his side several irrigations should be given at each session, a small amount of fluid being run in and immediately withdrawn. At the tenth to fourteenth day, according to the rapidity with which recovery has been accomplished, the catheter should be taken out, and the irrigations thereafter given through the urethra each day, until it can be demonstrated that the bladder is perfectly free from infection.

Resection of Diverticula.—Young's intravesical method is carried out as follows:[71]

The opening into the diverticulum is located, explored, and, if necessary, dilated with forceps. Into this orifice a glass tube is inserted to the full depth of the diverticulum and immediate suction with the electric air pump is commenced. It is usually evident almost at once that the mucous membrane has been drawn against the orifice and the tube is then moved very slowly outward for a short distance, the suction being continued until the mucous membrane of the diverticulum is seen coming up inside the glass tube, where it sometimes rises as high as 2 inches above the bottom. The tube is then very slowly withdrawn, the mucosa of the diverticulum which comes with it, being caught with a toothed clamp as soon as the end of the tube comes within reach. The tube being now removed, the intravesical delivery of the diverticulum is completed by traction, the operator applying sharp-toothed clamps about the circumference, and, if the sac prove so large that there is likely to be difficulty in delivering the entire diverticulum, further dilating the orifice. When the entire pouch has been turned inside out within the bladder, a circular incision is made around the neck of the diverticulum, through the mucous membrane, which has been elevated at one point for this purpose. From here the entire mucous lining of the sac can be readily peeled off and removed entire. The dissection is best done with a gauze-covered finger, pushing down all underlying structures, avoiding hemorrhage and injury to the ureter, the tissue removed consisting solely of mucosa and submucosa. A cigarette drain is so placed as to lie without and to one side of the bladder, and extending far enough to touch the collapsed cavity from which the diverticulum has been removed. The opening from the diverticulum into the bladder is closed by suture. The incision through the bladder wall is then sutured about a rubber drainage tube, or closed entirely, leaving a retention catheter in place.

Marion's Procedure.[12]—If possible, a catheter should be inserted in each ureter, and in any event, a sound must be placed in the ureter on the side corresponding to the diverticulum. Immediately before the intervention the bladder is filled with a mild antiseptic solution. With the patient in the Trendelenburg position an incision 10 cm. in length is made in the median line beneath the pubes. As soon as the bladder is incised it is held open with a Legueu retractor. An attempt is then made to turn the diverticular pouch inside out, like the finger of a glove. If this succeeds the base of the inverted sac is clamped and the sac resected, the vesical wound being then sutured with catgut in two layers. If the attempt at invagination fails, a transvesical method must be employed, combined with certain extravesical maneuvers.

The bladder is freed from the pelvic walls and the peritoneum, and if this be accidentally broached, it must immediately be sutured.

The bladder wall is incised and a wide resection made of the septum between the bladder cavity and that of the diverticulum, the section being carried as far as the connecting orifice between the two cavities. This permits the next step in the procedure, which is the freeing of the diverticulum. The operator now introduces his index finger and gently separates the wall of the pouch from any adhesions which it may have formed with adjacent pelvic viscera, at the same time drawing it gradually into the vesical cavity, the technic employed being the same as that commonly used in reducing a previously isolated hernia. If the ureter is included in the diverticulum, or if it is closely adherent to its wall, the duct will have to be severed and replanted in the bladder, according to Payne's technic. The diverticular pouch once drawn within the bladder, will remain attached only by a pedicle which can easily be cut through. The diverticular orifice is sutured in two layers and the operative incisions are closed about suitable suprapubic drainage.

Combined Methods.—It is evident that all cases of vesical diverticula are not amenable to the same treatment. In a case reported from the Mayo Clinic,[42] no less than three of these sacs were found; a large sac opening in the left ureteral area was excised extravesically; a small sac of about 30 cc. capacity, lying above the left meatus was inverted into the bladder and removed intravesically, and a small diverticulum of several cubic centimeters was merely stitched over. The patient made a good operative recovery.

In the first procedure the bladder was opened suprapubically, and a couple of fingers placed in the diverticular orifice so as to exert traction upon the sac which was then dissected out and cut off at the neck. The second pouch was inverted within the bladder according to the technic published by Young in 1906,[72] which consists of making a circular incision through the mucous membrane around the diverticular opening, grasping the diverticular mucous membrane with hemorrhoidal forceps, invaginating it, either by traction upon the forceps or with the assistance of a finger outside the bladder, and completing the excision after the diverticular pouch has been turned inside out within the bladder cavity. This method is not applicable when the diverticulum is very deep, or if it has formed adhesions to surrounding structures.

Surgical Treatment of Ruptured Bladder.—When rupture of the bladder is strongly suspected, even if the diagnosis has not been absolutely established, it is best to perform a suprapubic cystotomy, which will establish drainage, and prevent extravasation of urine into the extravesical tissues if rupture has taken place, and at the same time permit the vesical cavity to be inspected. If this is done very shortly after the accident occurs it may be all that is necessary, for extraperitoneal rupture may be all that has occurred, and the establishment of good drainage will serve every purpose. In most instances, however, the possibility of rupture of the bladder will not be thought of until

considerable time has elapsed, and extravasation will have already taken place. It will then be necessary to establish drainage of the tissues according to the method advocated by Fuller.[25]

Operative Treatment of Extraperitoneal Rupture.—With the patient in the knee-chest position, converging incisions are made on either side the rectum, long enough to permit the rectum to freely retract as the perineal dissection liberates it from its natural anchorage. The rectal flaps will retract to such an extent that the prostate will be exposed when the tissues included between the incisions has been dissected free, making that organ a superficial rather than a deep-lying structure. While the dissection is in progress the operator's other hand employs its forefinger in the rectum to serve as a guide, the path of dissection following a line just outside the muscular perineal body, within the perineal fascia. If the transverse flap is started well below the anus, the rectal sphincter and its encircling bloodvessels will not be damaged. The perineum will retract as the dissection is carried forward, so that the fascia propria of the pelvis with its median raphé comes into view, and when this has been severed entrance to the bursal space separating the rectum from the prostate is effected. The operator's right forefinger is now introduced into this space and the prostate and seminal vesicles digitally separated. The right finger tip should be bent down to guard against perforation of the rectal wall, and the left forefinger kept in its original position in the rectum. Should fibrous bands, too tough for finger separation be encountered, a scalpel guided by a director may be introduced to cut the bands, after which digital separation is resumed. The seminal vesicles are opened as in the performance of a regular seminal vesiculotomy (page 283). The vesicles and the deep limits of the dissection are then packed with gauze, a space being left between the packing and the rectal wall for the insertion of drainage tubes.

Surgery of Intraperitoneal Rupture.—Three important points in the management of rupture of the urinary bladder have recently been emphasized by Crosbie: (1) The importance of free suprapubic bladder drainage in all cases of ruptured bladder, whether the rupture be extra- or intraperitoneal. (2) That there is no necessity of flushing out the abdominal cavity in cases of intraperitoneal rupture of the bladder. (3) That it is not necessary to take the time to sew up rents in the bladder whether the rupture be extra- or intraperitoneal. With a $\frac{1}{2}$-inch rubber tube in the bladder the urine will flow out through that, as it is the path of least resistance. Nature will take care of the healing rents as they are bound to be fairly-well approximated. In his opinion the important thing is to establish drainage and get out as soon as possible.[18]

A less radical procedure is to open the bladder sufficiently to permit thorough exploration, and to repair the rent, if found, using two rows of Lembert sutures for closing the properly freshened edges. Drainage is always of the utmost importance, and should be maintained

as previously suggested, until healing takes place. The authors always place a drain in the peritoneal cavity if there has been an extravasation of urine into it.

Surgical Correction of Ectopia Vesicæ.—The condition of the victims of extrophy of the bladder is so pitiful that any measures for their relief, no matter how uncertain the outcome, will usually be welcomed by the patient and his friends. Such interventions should be undertaken as early in life as possible, although the deformity has been successfully corrected even as late as the fortieth year. As Boogher has put it, "As 65 per cent of these cases develop infection early in life and are lost, and the operative procedures are at worst on a par, efforts at radical relief should be made."[7]

Two classes of intervention are used in the effort to correct this condition: (1) Extirpation of the bladder and disposal of the urine by artificially created outlets—ureteral anastomosis: (2) Bladder repair and the establishment of urinary control. The first class will be considered in the section on surgery of the ureters (page 580).

External Plastic Operation.—The first attempt made to close the defect in the bladder wall in accordance with modern surgical methods, was that made by Roux in 1852. The most widely employed of the earlier procedures was that of Sonnenberg performed upon the male, which consists of freeing the posterior vesical parietes from the peritoneum, covering the exposed peritoneum by two lateral flaps, freeing the ureters beneath the edges of the flaps at the point where the epispadiac urethral sulcus begins, and inserting the ureters into the newly-formed bladder wall. These earlier operations were all attended by a high mortality-rate; Sir Frederick Treves placed it at 20 per cent, and he added that "few operations in surgery are attended with a larger percentage of partial or complete failures than are flap operations for ectopia."

The most used operations recently are those of Wood and Thiersch. Wood's procedure consists in turning down a pyriform flap of skin and fascia from the abdominal wall near the umbilical region, so that the cutaneous side of the flap will serve as a lining membrane for the new anterior aspect of the bladder. Lateral flaps are turned up from the inguinal region and rotated inward toward the median line so that the upper and inner margins are brought into juxtaposition, and can be united by interrupted sutures. Those surfaces which are left exposed by the turning down of the flaps are either sutured or left to heal by granulation. This method requires a number of operations and is, therefore, a decidedly tedious matter. The disadvantages of this operation lie in the fact that the hair follicles upon the skin surface which is now within the bladder, continue to produce hair, which serves to form phosphatic deposits in the artificial vesical cavity, which may be very troublesome, and even need to be removed by operation. It is, however, possible to depilate the skin before the flap is turned down.

This operation, though it reduces the wide expanse from which urine

can escape, does not in any way relieve the incontinence, so that the most it can accomplish is to make practicable the use of a receptacle for collecting the urine as it escapes.

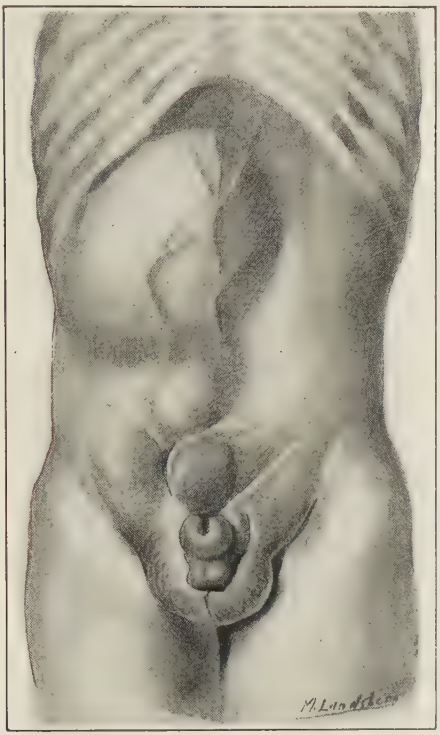


FIG. 160.—This is a drawing of a patient who had his extrophy of the bladder closed by a German surgeon after 7 attempts, apparently in accordance with the method suggested by Wood. When he presented himself at the Brady Foundation (New York Hospital) in 1924, his bladder was covered but he had complete retention, due to stricture of the repaired vesical orifice. He stated that he never had control of his urine. His urine was badly infected. His right kidney was tremendously distended and had to be drained under regional anesthesia. It proved to be a large pyonephrotic sac. The patient recovered from the immediate effects of the operation, but died of uremia and septicemia some days later.

Direct union of the fissured edges is sometimes attempted, according to the technic of Trendelenburg. He endeavored to do away with the pubic diastasis by cutting through on both sides of the sacro-iliac synchondrosis. A mechanical device which pressed the symphysis together was then applied, and the patient immobilized for several weeks, the bones being later sutured together. In order to make a sphincter capable of contracting, free incisions are made in the upper wall of the funnel formed by the bladder, and the urethra in its *pars prostatica,* uniting the resulting wound by Lembert sutures. According to Thiersch, this technic is only applicable when a large portion of the

bladder wall is present, for otherwise no reservoir could be formed for lack of material.

Transplantation of the ureters is now generally regarded as the best means of dealing with this distressing condition. It is almost three-quarters of a century since Simon[61] first attempted to direct the orifices of the ureters into the rectum his argument being that in the human embryo the cloaca serves as a common reservoir for both urine and feces, as is the case with birds, and that there is no fundamental reason why this should not be done in the human adult. The great drawback to this procedure, however, is the danger of ascending infection, which has persistently nullified the efforts of surgeons through many decades. But with increase in surgical skill and improvement in aseptic methods this danger has been lessened, so that most operators can subscribe to the remarks of Lower[48] that the danger of a transplanted ureter is no greater than that from one exposed in the extrophied bladder, and he believes moreover, that within the rectum with its natural defenses, it must be less in danger than when it is transplanted to the skin, as into the loin, where it meets with no such natural defense.

TREATMENT OF VESICAL PATHOLOGY BY NON-OPERATIVE MEANS.

Diathermia.—During the past few years the application of heat to vesical conditions has received a great impetus through the improvement in methods of using electrical contacts for its generation. Diathermia provides a form of heat which can be applied *internally*, which offers an immense advantage over any kind of *external* application. With the proper instruments it is possible to increase the voltage from the ordinary current derived from the lighting supply to as high a frequency as is desired, and at the same time increase the frequency of oscillation. The relative amount of current to which the patient is being subjected is indicated by a meter, the scale of which is graduated in milliampères. An electrode having a thermometer attachment should be used if possible, so that the degree of heat production may be more exactly indicated. The exact density of the current varies with the amount of current, the resistance of the tissues through which the current is passing, and the area of electrode contact with the patient's body. The upper limit of safety is generally set at 100 milliampères per square inch of electrode. When electrodes of equal size are used, the greatest amount of heat will be generated midway between them, but if one electrode is larger than the other, the greatest concentration of heat will be a short distance below the smaller one. "This fact," says Corbus,[17] "constitutes the key to success in diathermy for by means of variation in electrode size and shape, we are able not only to produce heat in the depth of tissue but to localize it within a given area."

The skin surfaces are protected by gauze pads soaked in warm hypertonic salt solution which are placed between the cutaneous surface and the electrode. Shaving soap may also be applied to the skin, but has the objection that the electrode may slip over the edge of the gauze or in prolonged applications the drying-out process may destroy its efficiency. Intimate contact of all the electrodes is most essential. Where special electrodes are used they must be designed to fit the contour of the surface or lumen smoothly. Cutaneous electrodes should be held in place by sand bags, adhesive strapping or other suitable means. It is advisable to increase the current slowly, taking several minutes before inducing the maximum amount of heat. At the completion of the treatment the current should be reduced gradually over a period of two or three minutes. Skin abrasions, open or bleeding wounds, should not have electrodes placed directly over them.

Palliative Treatment of Bladder Conditions.—After the bladder has been evacuated through a catheter, it is filled with boric acid solution and this is in turn drawn off until it returns clear. The bladder is then distended to its capacity and the catheter withdrawn. The active electrode is in the form of a metal cylinder or sound, while a flat metal plate 5 inches square, or a piece of wire netting of the same dimensions serves for the inactive electrode. At the beginning of treatment the patient is beneath the plate which lies upon the symphysis pubis; in the second part, he lies upon it. A single treatment usually consists of the application of through-and-through heating for a period of twenty minutes, using from 600 to 800 milliampères. Where through-and-through effects are desired, the electrodes must be of equal size, one being placed beneath the sacrum and the other above the symphysis.

Following the removal of a tuberculous kidney there is often a peculiarly distressing and persistent bladder contraction and irritability, and for this Corbus and O'Conor particularly recommend the use of through-and-through diathermia, which tends to increase bladder capacity, and at the same time lessen tenesmus and reduce the frequency of the calls for micturition. Used in connection with other measures, diathermia has been found very helpful in this most unsatisfactory class of cases.

Fulguration.—High-frequency electric coagulation has now been for some years the method of choice for the extirpation of benign neoplasms of the bladder. It is important, however, that the diagnosis be fully established, for the treatment is not favorable for all malignant growths, so that the distinction becomes of considerable moment. Thomas[65] stated emphatically a few years ago that he had never seen a case of true papilloma, whether multiple or single, that was not destroyed effectively by high-frequency electro-coagulation, nor a single case of carcinoma involving the pedicle or bladder wall that was cured by the electric spark.

Technic.—The catheterizing type of cystoscope is employed, and through it the insulated electrode which is connected with the Oudin resonator, is passed until its tip invaginates the surface of the growth. The spark gap between the poles should be from 1 to 3 mm.; the current should never be so strong as to induce great pain. The first effect of the current upon the growth will be the appearance of bubbles rising through the fluid used to distend the bladder, and soon a blanching of the tissues will be noticeable. This is due to dehydration which destroys the vitality of the tumor tissue, which will thereafter slough off. It is hardly necessary to emphasize the care which must attend the operator's every motion, for should the normal tissues of the vesical wall be touched, there is great danger of producing a perforation. Cauterizations should never be given oftener than twice a week, and often longer intervals between treatments will be necessary, depending upon the amount of cellular reaction which occurs.

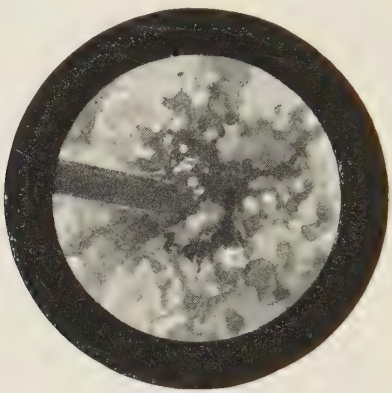


FIG. 161.—The electrode is seen plunged into the center of the papillomatous mass. As the current is turned on and the cauterization begun, bubbles are seen rising from its end. The tissues become blanched and later are carbonized.

Sacral anesthesia may be necessary in certain highly nervous patients, but in general the treatments can be carried out without anesthesia of any kind.

Radium Treatment.—During the earlier employment of radium in the treatment of inoperable malignant neoplasms of the bladder, it was customary to perform a previous suprapubic cystotomy, and implant the malignant area with one or more centers of radio-activity. The method did not prove very satisfactory, and though it found a considerable usefulness as a prophylactic application after surgical removal of vesical malignancies, on the whole radium did not offer much aid in combating these lesions.

Intravesical application of radium emanation has however, given a new impetus to the use of this therapy. The present indications

for the use of radium in bladder malignancies has been recently summed up as follows:[39] (1) As an adjunct to fulguration; (2) in the aged and debilitated, patients refusing surgery, or where surgery is contraindicated for any reason; (3) in small pedunculated growths which appear benign but are pathologically proved carcinomatous, although there is no evidence of infiltration around the base; (4) in recurrences following operative removal of primary carcinoma or the fulguration of papillomata.

Implantation of radium emanation "seeds" appears to be the best method of applying radium to bladder tumors which has as yet been devised. Smith of Boston[62] warns against implantations in a growth more than 3 cm. in diameter lest the resulting necrosis be so great as to induce a fatal toxemia. It has been found, however, that by using very minute capillary tubes, containing no more than 1 mc. of radium emanation, or in most cases as little as 0.5 mc., the area of necrosis surrounding each "seed" is greatly reduced, and this has the added advantage that more units of radiation may be safely employed. The present method of implantation is entirely an intravesical operation, and with the employment of improved implements, such as the McCarthy cystoscope and the Muir cystoscopic radium emanation seed implanter, is accomplished with such speed and accuracy as to offer the highest inducements both to patient and medical attendant, to undertake radium treatment in preference to any other form of therapy.

Technic.—The technic is very simple The radium seed implanter is passed through a suitable cystoscope, after the patient has received proper preliminary preparation including sacral anesthesia. The "seeds" are placed in the loading slot by an assistant and driven in one after another without the necessity of withdrawing the implanter from the cystoscope. The growth is all the while in full view so that the operator can place the "seeds" accurately, always allowing at least 1 cm. of distance between each tube.

In case of only a small growth it is always possible to complete the treatment in one session. Occasionally it may be necessary to do it in two sittings, but results are far more satisfactory when all the tubes can be placed at one time. Implantation is first made at the edge of the growth and later in the middle. Care must at all times be exercised not to place any tubes in the normal tissues of the bladder wall, for radium, almost as surely as fulguration, is likely to produce a perforation of the vesical parietes, which would lead to most disastrous consequences. Hyman warns that the nearer a tumor is situated to the vesical sphincter, the more care should be taken in the dosage employed, for the inflammatory reaction following radiation of a tumor so situated is likely to be more severe than in a growth located further back in the vesical cavity.

Gold and platinum radon seeds are now finding great usefulness in vesical malignancy. They are equally applicable through a suprapubic

incision, or by way of the cystoscope, and the adequate filtration which they provide eliminates all necrosis.

Surface radiation is usually employed in addition to the seed implantation, except in the very small growths. The radium emanation is placed in containers which are carefully screened so as to cut off all but the penetrating gamma rays, the beta and secondary gamma rays being harmful to the intervening healthy tissue. The exact dosage will vary according to the needs of the individual case. Fortunately there are at present several corporations equipped to prepare radium and its emanation for therapeutic use, and the precise requirements of any particular lesion can be gauged and the proper dosage assigned for each case.

Reaction follows any radium implantation, and this may persist anywhere from two to five weeks. Should a second implantation be necessary, it must be delayed until all evidences of reaction have departed. Cystoscopic observation will show that the implanted tumor gradually whitens and sloughs off, this sloughing process sometimes occupying a space of several months before the growth wholly disappears.

Local and Medicinal Treatment.—**Irrigation.**—Irrigation is most valuable in cases of chronic cystitis; in the acute conditions, instillations, such as those of a 25 to 50 per cent argyrol solution, acriflavine $\frac{1}{3000}$ to $\frac{1}{5000}$, protargol in a 2 per cent solution, or the more recently introduced mercurochrome-220, will be found of greater usefulness. In chronic cases, silver nitrate instillations may be employed to good purpose, they are too irritating for acute inflammations, and such mild solutions as potassium permanganate 1 to 6000 or 1 to 8000; or bichloride, 1 to 10,000, will be found suitable. Plain hot saline solution, if intelligently administered, is often a very useful adjunct, and boric acid solution, 2 to 3 per cent, cleans the bladder and does not irritate it.

The introduction of the Bulgarian bacillus when it is desirable to neutralize an alkaline urine has been advocated by Caulk[15] and used with success by Hagner[32] and others. Hagner's method is as follows: The bladder is first irrigated with sterile water (this is very important, as any antiseptic will probably prevent the growth of the Bulgarian bacillus); 3 or 4 tablets are then dissolved in 1 ounce of sterile water, the mixture being well stirred, as these tablets are only in suspension. The solution is then injected into the bladder with a syringe and the patient told to retain it as long as possible. Improvement so immediate as to be almost miraculous has at times followed the application of this therapy.

Drugs by Mouth.—The question of attaining urinary antisepsis by the oral administration of drugs has been much discussed, but never satisfactorily solved. As Davis[19] has said, the compound ideally adapted for the purpose of internal urinary antisepsis should be chemically stable and relatively non-toxic and non-irritating; should be antiseptic in high dilution in urine of any reaction; and should be

eliminated unchanged in high percentage by the kidney. He adds sadly: "There is no such drug known." The large number of urinary antiseptics which have been tried and are ardently recommended by some, and as roundly condemned by others, is abundant evidence that none universally efficient has as yet been discovered. We will, however, make some attempt to discuss those which have so far most nearly approached the definition just quoted.

Hexamethylenamine or, as it is more commonly and briefly designated, *urotropin*, is described as pure, stable, non-toxic and inexpensive, is capable of being safely administered in large quantities without injury. It is excreted unchanged by the kidney and becomes active in the urine through the liberation of formaldehyde. While urotropin is not in itself germicidal, formaldehyde is recognized as a very efficient germicide. The splitting of hexamethylenamine into formaldehyde and ammonia takes place only in urine which is acid, however, this fact distinctly limiting the general usefulness of the drug.[60]

After making a very extended study of urinary antiseptics, Hinman[36] concluded that of all substances hexamethylenamine is the most efficient in the largest number of cases, but its limitations are so numerous and pronounced as to make its value felt only in selected cases; and it should not be given in the routine way that is at present almost universally practiced. In making use of this drug it is important to bear in mind that its action depends upon urinary acidity and the reaction time of the conversion of its elements into formaldehyde. The acidity of the urine is influenced by both metabolic and bacterial changes. In the absence of bacteria the reaction is usually acid, and even when neutral or alkaline from either disease or diet, regulation of the latter and feeding acid-producing drugs, such as acid sodium phosphate or sodium benzoate, will quickly render it acid. The alkalinity of the urine in infections which induce decomposition of the urea cannot, however, in many patients be changed by the administration of acid-producing drugs.

Hexamethylenamine is not efficient for urethral antisepsis, nor in those bladder conditions where sufficient time is not allowed for its concentration and the accumulation of formaldehyde, as in polyuria or frequency, or where continuous bladder drainage has been established.

Proflavine and Acriflavine administered by mouth in 0.1 gram and 0.05 gram dosage to normal individuals, were found by Davis to be secreted in the urine in sufficient concentration to render it an unfit culture medium for the colon bacillus and staphylococcus, *provided the reaction of the urine is alkaline.* But acriflavine was used by Helmholz and Millikin[33] in 3 cases of pyelitis in children, where there was alkaline urine, without producing any appreciable effect, even when the largest doses which could be tolerated had been given.

Methylene blue in a dilution of 1 to 150,000 will inhibit the growth of staphylococci. Doses of from 3 to 6 grains may be given four times a day for several days, but after this its use must be temporarily discontinued, as it has been found that the staphylococcus quickly adapts itself to contact with the dye, and becomes immune to its effects after a relatively short time.

Though the value of the various dyes as urinary antiseptics is still undetermined, it certainly appears that a study of their potentialities and efforts to extend and develop their usefulness would well repay those who are concerned with urological research.

Hexyl Resorcinol.—It has been recently claimed[34] that hexyl resorcinol fulfils all the requirements heretofore postulated as necessary in the ideal urinary antiseptic. It is bactericidal for all the usual organisms infecting the urinary tract. In the authors' clinic the average duration of time necessary for destroying various organisms was: For *Bacillus coli,* sixty-three and a half days; for *Staphylococcus aureus,* eighteen days; for *Bacillus proteus,* ninety-four and a half days; for *Bacillus lactis aërogenes,* ninety-one days, and for mixed infections, one hundred and thirty-three days.

Vaccine Therapy.—Vaccine therapy has been used to a considerable extent in conditions of bacteriuria, but there appears to be little unanimity as to its worth. Geraghty[30] in 1910 reported the results of autogenous vaccine therapy in a series of cases of "rebellious bacteriuria," as being "most discouraging." There was absolutely no effect upon the staphylococcus infection, and although it may be possibly of some value against a colon infection his results, even for this, were far from conclusive.

More recent observations offer decidedly greater encouragement. Baer[2] about two years ago described a number of cases, in the treatment of which all forms of vesical medication had proved absolutely ineffective. He finally gave up everything, and relied wholly upon autogenous vaccine therapy. In most of the cases he had to deal with a *Bacillis coli* infection, often mixed with staphylococci or diplococci. In the preparation of the vaccines employed cultures were first made, rinsed in physiological salt solution, killed at a temperature of 65° C. and stabilized by the addition of phenol, 1 per cent. Four solutions were prepared, their content varying from 5 to 25 million killed bacteria per cubic centimeter. The entire course of treatment should cover about five weeks, the injections being given in accordance with the acuteness of the cystitis; the usual interval is two to three days. Baer saw immediate improvement and no unpleasant reactions of any kind; seldom was there even the slightest elevation of temperature.

Diet.—Dietetic considerations are of great importance in the pathological conditions of the bladder, no matter what their origin. The reason for this is perfectly obvious, for although the modern urologist does not build his whole science upon the urinary indications, as did the medical men of the Middle Ages, the findings in the urine never-

theless remain of very great importance, and the effects of diet upon the urine, and of the urine upon the structures which have to do with its secretion, collection and evacuation, is always of the greatest moment in all vesical difficulties.

Urinary calculus is considered by many authorities to be due to a deficiency of alkaline salts, soda and potash, in the diet. As these minerals are found in green vegetables especially, the abundant use of this type of food is to be recommended to those who have a tendency to calculus formation. Friedenwald[24] states that in most instances too rich food, too large meals and an inactive life are the most potent dietary factors in calculus production. He offers the following suggestions: "Forbid strong drinks and all alcohol if possible; much meat and especially the nuclein-containing meats, as thymus, spleen, liver and brain; caviare, etc.; smoked, pickled and spiced meats, and rich foods in general. The fats and sugars, as well as the cereals, should be restricted. The diet should be made up of the plainer, well-prepared foods, and as far as possible, a vegetable diet should be prescribed. Water, especially the alkaline mineral waters, may be allowed in abundance." If the urine ceases to be acid, however, alkaline water must be discontinued.

Infection of the urine calls for a diet which will reinforce the effects of the therapeutic measures which are being applied at the same time, and these will, of course, vary in accordance with the nature of the infection and the kind of treatment which is being employed to combat it.

Cystitis is usually aided by the dilution of the urine by the free drinking of water, but under certain conditions it is better not to increase the tax upon the bladder capacity any more than is absolutely necessary. The diet in general, should be laxative and non-irritating, with avoidance of acid fruits and the use of potatoes in place of bread and cereals.

The directions for the diet of gonorrhea patients (page 327) may be of service to those who have cases of vesical disturbance under their care.

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CHAPTER XIII.

THE URETERS.

EMBRYOLOGY OF THE URETERS.

The embryology of the ureters has already been touched upon in describing the fetal development of the bladder, and in connection with the account of renal embryology, the ureters must necessarily be included, so that we shall make but brief mention here of some of the most prominent features of their special prenatal phenomena.

From the primary excretory duct in the fetus which has attained a length of from 4.5 to 5.3 mm., the anlage of the ureter may be detected as a hemispherical outgrowth which, in older specimens, will be seen to grow first in the direction of the vertebral column, then in later development, when a length of from 8.5 to 9.5 has been attained, to come gradually to form a curve which eventually flattens out until at length the ureter attains and maintains a cranial direction. Reaching the dorsal surface of the metanephros or permanent fetal kidney, it is then surrounded by a loose envelope of mesochyme, and with the development of the primitive renal pelvis into its permanent form, its connection with the radial outgrowths of the collecting tubules of this organ is established.

ANATOMY OF THE URETERS.

The ureter is the excretory duct of the kidney. In size it is very often compared to a goose-quill, varying in length from 12 to 14 inches. It has its origin opposite the lower pole of the kidney, and passing down and inward behind the peritoneum, eventually reaches the base of the bladder into which it opens by passing obliquely through the muscular and mucous coats of this viscus for a depth of almost 1 inch, finally emerging within a narrow opening, the *ureteral meatus*.

Course.—As the ureter passes obliquely downward underneath the peritoneum, it rests upon the psoas muscle, the right ureter passing close beside the inferior vena cava, above the iliac arteries, with the ilium on the right and the sigmoid flexure on the left. It crosses the brim of the pelvis on the inside, but not far from the point of attachment of the appendix. This particular anatomical relation should be borne in mind when attempting to make a differential diagnosis, for the pain of renal disease may give rise to a tender spot at this point, which can easily be mistaken for that due to an inflamed appendix.

The pelvic portion of each ureter passes before the sacro-iliac joint,

and leaving the obturator internus and its fascia below, passes away from the pelvic wall in order to make its entrance into the bladder.

Structure of the Ureteral Wall.—The ureter has a fibrous coat continuous with the capsule of the kidney, and likewise with the fibrous tissue of the bladder-wall; a muscular coat made up of an outer layer which is circular and an inner layer which is longitudinal; and, at its lower aspect, an additional external layer which is very thin, together with a mucous coat made up of two layers, the *tunica propria* or submucosa without, and a layer of stratified transitional epithelium within.

The anatomical structure of the ureter has been very minutely investigated by Satani, who found that the outer fibrous coat is of especial physiological interest because it contains numerous important nerves and bloodvessels. Nerve trunks which have their origin in the renal, vesical and spermatic plexuses, together with others from the inferior mesenteric and other ganglia, enter the ureter's outer coat, and by numerous bifurcations and anastomoses one with another, form a plexus between the fibrous and muscular layer at the interesections of which and along the course of the nerve fibers, ganglia of varying sizes may be observed.

The *muscular layer* occupies a full half of the thickness of the ureteral wall, though its depth varies at different levels and the structure of the muscular fibers also varies, in the upper end making a braided membrane, taking their course in all possible directions, while lower down, the layer formation is distinct enough to permit distinguishing three definite layers, outer and inner longitudinal and middle circular. The median section has three well developed layers, circular fibers in thick bundles forming a strong band. Toward the vesical end the circular layer gradually decreases, while the two longitudinal strata proportionally increase, so that in the lower third of the ureter the circular fibers form only a broken curve, lying between the longitudinal fibers which at this point are the main constituents of the muscular coat. After the urethra has passed through the vesical wall the circular fibers cease, leaving only the longitudinal layer, which also a short distance beyond disappears on the medial side of the ureter. The longitudinal fibers on the outer side of the ureter, however, can be followed to the level of its orifice.

No definite sphincter can be detected at the vesical termination, but there is apparently a mechanism which prevents reflex of the bladder content into the renal duct. It is probable that the oblique course of the ureter through the bladder wall has something to do with the prevention of reflux.

Mucous Membrane and Submucosa.—The mucous membrane and submucosa are innervated by a fine network of thin nerve fibers which supports a large number of single nerve cells or ganglia containing a number of cells. No secreting glands are observable, but in normal specimens diffuse lymphoid tissue or sometimes well-developed nodules, are found almost constantly in the coat in greater or less amount.

Sex Differences.—The course of the ureter necessarily varies somewhat in the two sexes. In the female it has its course parallel to the uterine cervix, lying perhaps $\frac{1}{2}$ inch from it, entering the bladder wall about opposite the median section of the vagina. In the male, entrance to the bladder is effected obliquely through the posterior false ligament, at a point about $1\frac{1}{2}$ inches behind the prostate, after passing between the bladder wall and the vas deferens.

Constrictions.—Although upon superficial inspection the diameter of the ureter will appear to be uniform throughout its entire length, actually, it has three constantly found constrictions. The proximal constriction is at the lower pole; the middle constriction may be found at the point where the iliac vessels come in contact with the ureter; and the third constriction is located at the lower ureteral meatus, the circular fibers here forming a sphincter which makes this the narrowest portion of the entire duct.

Blood Supply.—The arterial supply of the ureter's fibrous coat is carried longitudinally in the larger vessels, from which, as we have seen, smaller arteries branch off at intervals, anastomosing freely and entering the muscular coat of the ureteral wall in all directions. In the submucosa the arterial vessels unite in a second plexus, the meshes of which still retain the longitudinal direction. Here capillaries have their origin, in their turn passing inward and outward to supply the muscular and epithelial layers. The blood supply of the ureter comes from the renal, spermatic and vesical arteries, in the female the ovarian replacing the spermatic.

Lymph Supply.—In the mucous and submucous coats of the ureteral wall we do not find so many lymphatics as are to be observed in the muscular coat. The lymphatic channels follow the course of the arteries, draining in three different directions; those highest up flowing in the same direction as the lymphatics of the kidney; those in that portion of the ureter which passes through the pelvis taking a mesial course so as to empty into the pelvic and lumbar lymph glands; while those in the lowest section take a downward path toward the vesical lymph glands. It is through this abundant supply of lymphatic vessels that tubercular infection so frequently ascends when its primary focus is located in the male genitalia.

ANOMALIES OF THE URETER.

Anomalies of the ureter, due to changes in its form during the period of fetal development, may be accompanied by similar abnormalities in the kidney, or, quite as frequently, will be encountered when the corresponding kidney is entirely normal. Abnormalities of the ureters are the result of some failure of the renal bud to develop properly, while an abnormal kidney is dependent upon some variation of the mesochyme.

Types of Anomaly.—Abnormalities of the ureter have been divided into two classes:[43] The incomplete double ureter and the complete double ureter. In the first class there is a common opening into the bladder, while in the second class each ureter has its individual vesical opening. Evagination of the excretory duct may be a cause of incomplete double ureter, where the renal bud has divided too early in the course of fetal development, or again, where the division has extended into the upper segment, the cleft thus made in the ureter itself becoming permanent, making possible almost any variation, from a slight exaggeration of the dimensions of the upper and lower pelvis, to an incomplete reduplication. Under these circumstances we will always see distinct pelves. The ventral ureter will have its origin in the upper pelvis where there will be but one orifice which will occupy a normal position.

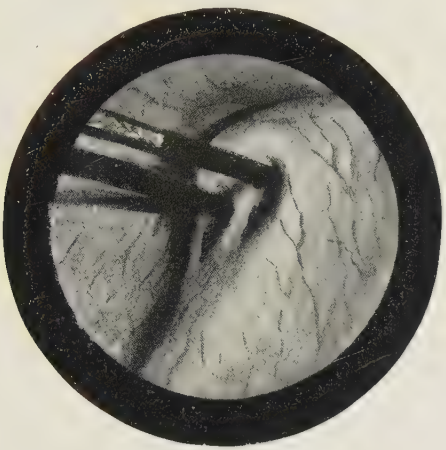


FIG. 162.—Complete double ureter, each of which has a catheter inserted. This condition occurs more commonly than was formerly supposed and should always be looked for in every cystoscopic examination.

When the renal bud is so completely cleft as to be affected by the shortening of the segment of the Wolffian duct which lies between it and the cloaca, each of the divisions may develop a separate opening into the duct, which will result in the formation of a double ureter. When we have a complete double ureter the one coming from the upper pelvis will empty by the lower orifice in the bladder, this orifice being found in the area between the higher opening of the dorsal ureter and the opening in the genital duct.[13] When there is a fused kidney the two ureters may each follow a distinct course making separate entrances into the bladder as under normal conditions; or one ureter may have a normal termination and the other end in some part of the genital tract other than the bladder. In the male such an abnormal point of discharge may be in the prostatic urethra, in the ejaculatory duct or

the seminal vesicle; in the female, in the urethra or vulva. Occasionally both ureters have been observed to run parallel all the way from the kidney to the bladder being enclosed in a common outer covering. The normal ureter on the duplicated side usually empties through the normal orifice into the bladder, though many specimens have been exhibited where the duplex ureters joined before piercing the vesical

FIG. 163.—Incomplete unilateral duplication. This patient had pus in catheterized bladder urine. No pus appeared in the specimens obtained from each ureter. A pyelogram was done upon the left side. The first picture showed the normal pelvis seen above. The second picture, here shown, was made while injections were being made into the catheter which was drawn out to a point about 1 inch from the ureteral orifice. The lower pelvis was then discovered with its ureter. The junction of the two ureters occurred about 2 inches from the ureteral orifice. Pus-laden urine was obtained by collecting specimens from a point just within the ureteral orifice, thus properly fixing the source in the lower renal pelvis.

wall, their combined content passing through a single orifice. Unilateral bifid ureter, most frequently on the left side, is a common form of this anomaly.[26]

Frequency of Occurrence.—It is probable that ureteral anomalies occur with much greater frequency than is commonly supposed. Often the condition is observed only at operation or autopsy, the abnormal arrangement having given absolutely no indication of its existence.

But in general, it may be assumed that when either kidney or ureter vary from the normal to any great degree, they will be less able to bear the continued strain of function, and will also be less resistant to infection or trauma than normal organs. In a report recently made upon 23 cases of kidney and ureteral anomalies[13] there were 2 single kidneys, both the seat of infection and 1 presenting a calculus obstruction of the single ureter; 1 horse-shoe kidney the seat of tuberculosis; and 6 cases of reduplication of the renal pelvis, all showing pyelonephritis. Six of the 23 patients had anomalies of one or both ureters, and in every case there was a renal infection. The authors presenting these cases were led to conclude that anomalies of the ureters interfere with kidney drainage, thus predisposing to infection.

Association with other Anomalies.—Ureteral abnormalities are frequently found in conjunction with those of other organs more or less remote. Thus in a case of single ureter and kidney[22] there was a mass overlying the pelvic brim on the left side, while cystoscopy revealed only one ureteral orifice which was located upon that side. Abdominal exploration showed that there was complete absence of the uterus, tubes and ovaries, the mass on the pelvic brim proving to be the left kidney, the right being missing entirely.

In another case, a single ureter divided and drained both kidneys. In still another, the existence of four ureters was discovered by accident; both supernumary ducts opened $\frac{1}{2}$ inch in front of the normally situated ones, and in a line between them and the urethra. In order to determine the relation of the ureteral orifices to the distribution in the kidney, both left-side ureters were catheterized. With the catheter in the ureter which empties nearer the urethra pyelography was undertaken, and later the second catheter was injected and another radiograph taken. This demonstrated the existence of a double pelvis, the upper one corresponding to the ureter which opened nearer the urethra.

This same observer has seen 13 cases where the patient had three ureters, 9 with the extra duct on the right side, 4 on the left. Most of them were seen during examination for conditions in no way related to the ureteral abnormality. Another observer reported having seen 5 similar cases, 2 of them within a single month. The possibility of ureteral abnormality would, therefore, seem to be one of which the urologist should never lose sight, and its recognition may frequently serve to illuminate what would otherwise be a hopelessly obscure diagnosis.

Bilateral Duplication.—Bilateral duplication of the ureters, while not so common as the occurrence of a supernumerary ureter on one side only, is yet reported quite frequently. In a man, aged twenty-four years, who came under operation for hypospadias, the cystoscopic examination of an otherwise normal bladder showed two ureteral orifices on each side, in relatively the same position, that is, in the lateral angle of the trigone about 1 cm. apart, the second duct being behind

and to the outer side of the first one. The appearance of each opening was normal, and urinalysis was wholly negative. The existence of the anomaly was confirmed by radiography. In another case which came to autopsy (death being due to tuberculosis of the lungs, which had caused secondary amyloid degeneration of liver and kidneys), the kidneys were normal in form and gave no indication that the parts of either renal organ corresponding to the ureter had ever been separate from each other. The ureters on each side had the course and relations presented by normal ducts, but at the point where they came into relation with the ductus deferens they were apparently fused into a single thick walled tube, so that unless the interior of the bladder had been carefully examined, the fact that the lumen of each duct remained distinct might have readily been overlooked. The medial openings of the ureters were 1 inch apart and nearly the same distance from the internal urethral orifice.[45]

The length of time which such abnormalities can exist without being suspected by competent medical authority is well illustrated by a case reported from England[39] where the patient, aged forty-three years, first suffered from dysuria, menorrhagia and bearing-down pains. From time to time thereafter she underwent various gynecological and urological procedures, none of which, however, were referable to the ureteral anomaly, until, at the age of sixty-three, a parovarian cyst of the right broad ligament was diagnosed. On opening up the peritoneum to dissect the cyst, this was found to have a limb which could be traced to the pelvis of the right kidney. When this hydroureter had been removed and examined it was discovered that a second ureter was present upon its inner posterior aspect, this proving under the microscope to have the structure of a normal duct. Though the account of the gynecological findings in this patient reads like the catalogue of a pathological museum, there is no evidence that any of her afflictions were due to the supernumerary ureter, the cystic dilatation of the normal ureter being accounted for by the discovery of two calculi at its base.

INJURIES TO THE URETER.

The subject of traumatic injury to the ureter can hardly be considered apart from that of injuries to the kidney. Usually the excretory duct shares in the trauma to the organ which it drains, and except in those instances where the ureter suffers damage during the course of an abdominal operation on some adjacent organ, injury to the ureter, the kidney remaining untouched, is decidedly rare. Henry Morris,[42] in the 1884 and 1901 editions of his text-book on disease of the kidney and ureter considered all the cases of subcutaneous injury to the ureter which he had found in the literature, and although in the second edition he added 8 cases to those first considered, making 24 altogether, of these he felt that but one-half were undoubted injuries of the ureter alone. Some years later, the subject was again reviewed by Blauel,[5]

who could record but 12 cases of subcutaneous injury to the ureter, and in 1916, 7 more, including 1 of his own, were added by Bugbee in this country.[12]

Diagnosis of Traumatic Injury.—In a very excellent discussion of the diagnosis of this unusual traumatic injury, Dumitresco and Buia[20] consider it from two points of view; when the patient is seen immediately after the accident, and when several days have elapsed between the receipt of the trauma and the first examination. When examined it is necessary to differentiate the injury from a contusion in the neighborhood of the ureter, a rupture of the corresponding kidney or renal pelvis, or from a rupture of the bladder. The differential diagnosis of rupture of the bladder has already been considered (page 481) and renal injuries will be considered further on (page 605). If cystoscopy can be done the injured ureter will usually give some evidence at its orifice, and ureteral catheterization, if possible, should be done, at least on the opposite side. Examination of the urine frequently gives some information, and cystoscopic inspection will serve to eliminate the uninjured lower urinary tract as a source of bleeding or other evidence.

Treatment.—Treatment must, in the majority of cases, be surgical. If the ureter is merely contused, palliative treatment may prove all that is needful, but more often laparotomy will be imperative and the further handling of the case will depend upon the exact nature of the injury, whether it is possible to repair the ureter, or in the event of this proving impossible whether the kidney should be immediately removed.

Injury During Surgical Intervention.—Accidental injury to the ureter is most likely to occur in the course of extensive gynecological operations, especially the removal of large uterine fibroids, where the ureter has often been dislocated from its normal position by the pressure of the tumor mass. This may also occur where pus tubes or intraligamentous cysts must be extirpated. It is probable that unintentional severing or ligation of the ureter has taken place more often than either patient or surgeon has recognized, and that many postoperative deaths attributed to other causes are really traceable to this accident.[24] "Injuries to the ureters are by no means uncommon accidents," says Baldy, "even though few of them ever find their way into print."[3]

INFECTIONS OF THE URETERS.

The position which the ureter occupies, that is, a connecting duct between the kidney and the bladder, symbolizes in a way how interest in its physiology and pathology has commonly been subordinated to that in the more important organs. Yet, as Quinby[44] has put it, though the problems surrounding the ureter both in health and disease, are much fewer in number and of less importance than those which

concern the two organs which it connects, the ureter is by no means devoid of importance.

Elsewhere, we have already discussed the process by which infection, as, for example tuberculosis, passes through the ureter from bladder to kidney or *vice versa* (page 484). In a similar manner other infections invade it secondarily.

Primary Ureteritis.—Primary ureteritis is, we have recently been told,[51] still almost unknown or regarded with extreme indifference except by a limited few. Yet this author believes that obscure abdominal or pelvic pain can often be traced to inflammation in the lower ureter, and that a great many instances of dysuria are the result of such an infection, which is due either to a lymphatic extension, often from a chronic infection of the urethra, or exists as a metastasis from a more distant focus. The majority of these instances of ureteral inflammation have been observed in the lower section of the tube, usually associated with considerable dysuria. The extreme pain which is a striking feature of this condition is attributed by Clinton K. Smith to the action of those muscle fibers of the trigone which extend upward along the ureter, and which tug on this anchorage during the muscular contraction of the trigone drawing open the bladder outlet.

If the seat of the inflammation is in the median portion of the ureter, the pain will be referred along the course of the duct itself, and on palpation there will be tenderness in this region. Occasionally, the entire length of the ureter will be involved. The infected ureter eventually becomes thin, loses elasticity and the whole becomes dilated and elongated. It resembles somewhat a piece of old flaccid rubber tubing.

Primary infections are rare but not unknown. Tuason[54] has recently reported 6 cases where the ureter was found to be the site of an inflammatory process, independent of and uninfluenced by the condition of its kidney. One similar case occurred on the urological service at the New York Hospital. The entire ureter was filled with nontuberculous granulations, but the kidney pelvis and parenchyma were normal in every respect.

Ureteritis Due to Focal Infection.—That many obscure bladder symptoms may be the result of ureteritis due to focal infection was a contribution made by Hunner[29] some five years ago; his opinion being now very generally accepted by urologists. Ureteral stricture or simple chronic ureteritis may be the outcome of diseased conditions in the tonsils or gums, although the sinuses seem to be the starting-point in many adult cases, and a few probably originate in the intestinal tract. It is possible that the original infection may first be arrested by the lymph glands in the region of the ureter, the causative organisms then being taken up by the walls of the duct, with resulting inflammation and infiltration. In many cases of ureteritis, the infection will descend sufficiently to involve the trigone, thus producing highly distressing vesical symptoms, all of which subside without any atten-

tion being paid to the bladder after suitable treatment of the ureteral condition.

Gonorrhea.—Gonorrhea of the ureters can hardly be classed as a separate entity in considering the pathology of these ducts, as it occurs only as an extension of vesical or renal gonococcic infection. So far as we have been able to discover no cases primary to the ureter have ever been reported. It seems that gonococcal infection of the bladder is decidedly uncommon (page 483) and renal infection from this organism is apparently very rare indeed, Lehr[36] in 1912, being able to find records of but 20 cases. According to Thomson[53] in conjunction with gonococcal cystitis, a further extension of the infection may pass to the ureters, to the pelves of the kidney, and even to the kidneys themselves. Although in many cases where this spread of the disease has occurred, secondary pyogenic organisms such as staphylococci and *Bacillus coli* may be found, yet there is no doubt that a pyelitis and pyelonephritis can be caused by the gonococci alone.

It seems to be generally conceded that renal gonorrhea is, in most cases, an extension of a gonorrheal cystitis by way of the ureter. A number of writers cite Luys' mention of Murchison's case (we are unable to verify the reference), in which a gonorrheal cystitis was followed by an inflammatory condition in the entire ureter. Bransford Lewis[37] has given a graphic account of a patient who suffered continual reinfections of gonorrhea, although every avenue of infection appeared to be closed. Finally cystoscopy demontrated three ureteral orifices, and the insertion of wire into ureteral catheters (this was before pyelography became practicable), showed the presence of two functionating ureters on the left vesical wall, the urine obtained from one of which was loaded with gonococci, while that from the other, as well as from the single ureter on the right, was practically normal.

The close relationship between the ureter and the renal pelvis makes it difficult, as Thomson has pointed out, to assign the location of the gonococcal infection to any definite area of the upper urinary tract. Acute infection is decidedly unusual, the more common finding being a subacute or chronic condition, due to an ascending infection. It occurs chiefly when, in the lower urinary tract, there is an associated inflammation and obstruction to the outflow of urine. In such cases the infection is usually bilateral.

Symptoms.—Symptoms are not very arresting. There may be a slight rise of temperature, and some pain over the angle found between the last rib and the erector spinæ muscle. There may be intermittent pyuria, or the urine may be continually loaded with pus and the gonococcus be demonstrated in the sediment. The final diagnosis is dependent upon cystoscopic examination, when the orifices of the ureters will be seen to be inflamed and patulous, and a little pus may be seen oozing from them. Catheterization of the ureters and subsequent examination of the catheterized specimen bacteriologically or by culture, will confirm the diagnosis.

Treatment.—Treatment of any gonorrheal infection of the upper urinary tract consists of rest in bed, the usual bland diet and abundance of fluids, together with the administration of urinary antiseptics and local applications through the ureteral catheter, pelvic lavage, etc. Vaccine treatment is also very generally recommended.

Tuberculosis of the Ureter.—Tuberculosis of the ureter is like gonorrhea, in most cases, a secondary infection occurring either in generalized genito-urinary tuberculosis, or when the kidney is the primary seat of infection. It is, of course, probable that, granting

FIG. 164.—Large distorted ureter such as is often seen with the more acute form of tuberculosis. This type of ureter does not usually have tubercles in its wall and it is not always necessary to remove it *in toto*.

that tuberculosis of the kidney arises from hematogenous infection, a primary focus can be implanted in the ureter in the same way. The ureter may become tubercular by tubercular deposits from the blood, as the ureter is supplied by the same bloodvessels as the renal parenchyma.[46] But it is probable that infection by continuity, either vesical from below, or renal from above, is a more frequent occurrence. Extension through the lymphatics is also another very probable route of infection.

Diagnosis.—The diagnosis must be reached by the same methods which we apply in establishing the existence of renal tuberculosis.

The great assistance afforded by roentgenographic examination has been emphasized by Braasch and Olson,[9] who observed that calcium deposits may occur with tuberculosis in the ureter, although less frequently than in the kidney. When it is present, a considerable portion of the ureter, usually the lower portion, is involved. The shadow

Fig. 165.—The ureter and kidney pelvis here shown are typical of chronic tuberculosis of the upper urinary tract. The kidney pelvis is distorted and shaggy. The ureter has a feathery appearance which is due to the development of tuberculous granulations in its lumen. This type of ureter should be removed entirely at operation, as it is bountifully supplied with tubercles and, if left behind by the surgeon, might easily continue as a source of infection and pour tuberculous pus into the bladder, keeping up the irritation in that viscus.

may be several centimeters or more in length and outline the dilated ureter to a greater or less extent. The shadow is caused, either by calcareous deposits in the thickened wall of the ureter, or by intraurethral calcareous deposits. There is often a periureteral infiltration which, together with the thickened ureter, will often cause a tumor mass which can readily be palpated on rectal or vaginal examination.

STRICTURE OF THE URETER.

Conditions capable of producing ureteral stricture are so numerous that it seems remarkable that the views promulgated by Hunner some years ago should have remained so long unperceived, and it is still more incomprehensible that once the attention of the medical profession had been brought to the prevalence of this pathological condition, such a comparatively large proportion of this same body refused to accept Hunner's conclusions, or at least, accepted them with many reservations. At present however, Hunner's work is largely unquestioned, and it is to him that we are indebted for much of our present knowledge concerning a great variety of ureteral lesions.

Etiology.—Among the casual factors which may induce stricture of the ureter may be mentioned intra-ureteral conditions such as inflammation extending downward from the kidney in pyelitis, or the presence of any agent which will serve to produce inflammation of the ureteral mucosa; trauma, either from external accident, or surgical intervention; pressure from without, as that due to the presence of a tumor which encroaches upon the ureteral lumen, or the pressure which may be exercised by an external inflammatory process such as a chronic colitis or appendicitis, or in females, chronic salpingitis. By the term ureteral stricture we do not mean obstructive conditions which arise from neoplastic infiltration of the ureteral walls, or the kinks and torsions to which this duct is not infrequently subjected. Neither should we properly include obstruction or occlusion by stone, although, as is noted elsewhere (page 565) stricture is a not uncommon cause of the concretion of such calculi.

Congenital Stricture or Stenosis.—Congenital stricture or stenosis is usually one of two types, those showing a narrowing at the ureteropelvic junction, or very close to it, and those in which the lower end of the ureter displays some anomaly of development, such as stenosis or atresia.[11] In cases of the first type there is most commonly a congenital aplasia of the uretero-pelvic junction, so that its lumen is reduced to from 2 to 4 mm. and its diameter rendered proportionally smaller, the resulting tube being so narrow that little or no urine can force its way through it, resulting in hydronephrosis of the kidney which is thus deprived of its normal urinary outlet. Such a condition may exist for years unperceived, the hydronephrotic kidney gradually increasing in size, but causing no symptoms until it has attained enormous proportions, and may be nothing more than a thin sac of membrane. In other cases infection will invade the lesion, with resulting perinephritic inflammation so that attention is directed toward the ureteral condition before a large hydronephrosis has had time to form.

Congenital stenosis of the lower end of the ureter may be either a complete aplasia of this part of the duct, so that a certain section of it is altogether lacking and there is no evidence of any ureteral meatus in

the adjacent bladder wall; or it may merely be a narrowing, the meatus being in normal position, possibly with prolapse or cystic dilatation of that part of the duct which lies intravesically, or even a cystocele.

It will be recalled that the ureter has three normal points of narrowing; just before it enters the bladder wall; at the point where it crosses the pelvic brim, and close to its place of emergence from the renal pelvis. In the normal human fetus these constricted areas become exaggerated toward the end of the gestation period, with consequent increase in the dilatation of the remaining parts of the ureter. Such dilatations are always observed to be accentuated upon the proximal side of the constricted portion, the most marked widening being at

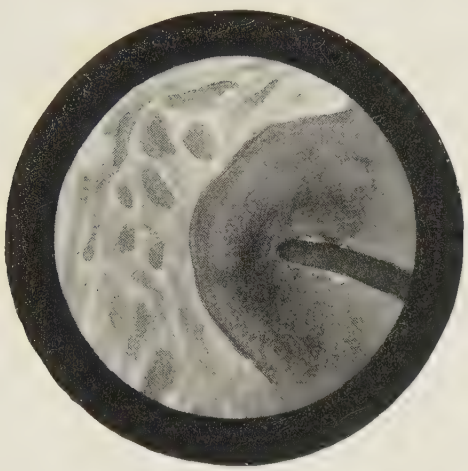


FIG. 166.—Ureterocele. This picture shows the balloon-like mass which alternately fills and collapses as the orifice functionates. It is easily repaired by dilating the orifice, slitting it with the operating scissors through the cystoscope, or by fulgurating a groove in its lower wall by means of the high frequency spark.

the middle third of the ureter, near the point of narrowing which occurs at the pelvic brim; or, less frequently, between this point and the wall of the bladder.

Congenital Twists and Kinks.—In the fetal ureter the occurrence of valve formation (page 311) or of twists and tortuosities is not at all uncommon. These spiral twists may be at any point, but are most frequently encountered at the junction of the upper and middle thirds of the ureter. Such abnormalities occasionally persist into post-uterine life, although the clinical occurrence of congenital stricture is very rare. Bottomley[6] in 1910, and Eisendrath seven years later,[21] collected altogether records of 67 cases which had appeared in the literature. Though mostly of anatomical interest only, in not a few instances the persistence of these congenital conditions gave rise to

symptoms which made operative intervention imperative. When the obstruction is at the lower end of the ureter, as a rule, this structure will be found tortuous and much dilated with a very thin wall, while the corresponding kidney will present a hydronephrosis, or possibly a marked primary atrophy. Though the ureter actually reaches the bladder, it will be found to end in a blind sac, and the cystiform protrusions of this blind ending frequently bring about well-evidenced secondary pathological changes in the bladder as well as in the opposite ureter, or even in the opposite kidney. Cases have been reported where it wholly obstructed the urethral orifice of the bladder, so that this viscus was greatly distended and enlarged, with subsequent urinary retention.

Symptoms of Congenital Stricture or Obstruction.—Though, as is the case with other ureteral anomalies, congenital stricture may persist throughout a long life without causing any symptoms whatever, the occurrence of such a condition as the growth of an abdominal tumor may bring them into evidence. Sometimes there will be symptoms like those of an abdominal infection, frequently conveying no suspicion of renal or ureteral involvement; or again, disturbance of the urinary function will be the only indication of anything abnormal. Urinalysis gives little aid in diagnosis even when infection has set in, but ureterography and pyelography, if the stricture can be passed, should serve to enable the modern urologist to make his diagnosis without much trouble.

Kinks and Obstructions Due to Aberrant Bloodvessels.—An abnormal vessel crossing the lower pole of the kidney may obstruct the outflow of urine from the renal pelvis. These vessels may be branches of the renal vessels, or may come direct from the aorta or vena cava.[16] If the kidney retains its normal position the presence of such aberrant vessels may never be recognized, but if it so happens that the kidney is ptosed or rotated, it will be likely to cause obstruction. It is probable that a so-called "floating kidney" will not induce any disturbance so long as its ureter is able to follow and adapt itself to the changes of position, but if the ureter is fixed by abnormal vessels, the sagging of the kidney will very shortly produce symptoms.

Dietl's Crisis a Ureteral Symptom.—These symptoms ordinarily take the form described in 1864 by Dietl, and since known as *Dietl's crises*. This observer attributed the symptoms to twisting or kinking of the renal vessels, or the ureter, by the downward movement of the kidney. Since his time, however, we have found that the "crisis" can occur when there is no abnormal motility of the kidney, and that it has no connection with obstruction of the renal vessels, but is due to obstruction of the ureter, which brings about an intermittent hydronephrosis. Mobility of the kidney, primary or secondary to the hydronephrosis, may aggravate the symptoms, but apart from the obstruction of the ureter, movable kidney is of little importance, although many symptoms are wrongly attributed to it.[48]

In the normal distribution of the renal vessels the main arteries and their branches pass in front of the renal pelvis to reach the hilum of the kidney, but those passing behind the pelvis, are, as a rule, at too high a level to obstruct the ureteral outlet. It sometimes happens, however, that an aberrant vessel may cross the origin of the ureter on its way to the lower pole of the kidney. At times, too, a similar tributary of the renal vein, or perhaps a vein and an artery, run together, or rarely, an additional artery may run from the aorta to the lower end of the kidney. Most commonly the aberrant vessel will lie behind and superimposed upon the ureteral origin. In some cases the abnorml vessel will cross the ureter without obstructing it, but if the kidney is unusually mobile some obstruction is likely to occur when the subject is in the vertical position, and this will lead eventually to dilatation of the renal pelvis. Any dilatation and pouching of the pelvis is likely to increase the tension upon the artery, which in turn, serves to increase the obstruction, and as the pelvis becomes more and more distended and the kidney tends to "float" downward because of its increased weight, the tense bloodvessels will exert more and more pressure on the ureter, causing inflammation and eventually producing a real stricture at the site of constriction.

Results of Urinary Obstruction.—Though Dietl's crisis has long been recognized as being due to these wandering vessels which produce a kink in the ureter and block off the flow of urine, it has been only since pyelography came into use that it has been possible to observe that such abnormal vessels may also produce other pathological conditions, recurring attacks of pyelonephritis, intermittent hematuria, bacilluria or chronic hydronephrosis. If the free flow of urine anywhere in the tract is prevented, there will always be a tendency to infection, and once this has taken place, it will not be relieved except by the establishment of free drainage. The symptoms which are produced by aberrant vessels are generally in direct ratio to the acuteness of the obstruction and the extent of the infection. Often the attacks of renal colic will continue for years before the cause is determined, if indeed, a diagnosis is ever reached. Exercise often brings on these attacks of sudden spasmodic pain which are severe and very characteristic, the pain radiating downward from the loin, and inward to the groin, often as far as the testicle. The differential diagnosis is by no means easy, and even a negative radiographic report for stone, cannot be taken as conclusive. Pyelography will be useful in helping to demonstrate early hydronephrosis, and if there is a diminution in the amount of urine during the time the pain is most severe, with an increase in the flow when the pain is subsiding, these observations also, will suggest a hydronephrosis. Cystoscopy with the injection of indigo-carmine may be of great service if utilized while the attack is in progress.

Treatment.—It is of the utmost importance to recognize and treat obstructions due to the existence of abnormally placed vessels before

serious damage to the kidney pelvis or to the ureter can take place. Division of the abnormal vessel will then be all that is required, whereas, when chronic hydronephrosis has been established, so that severe and long-continued pressure has set up a stricture at the origin of the ureter, or extreme dilatation of the pelvis has occurred, with correspond-

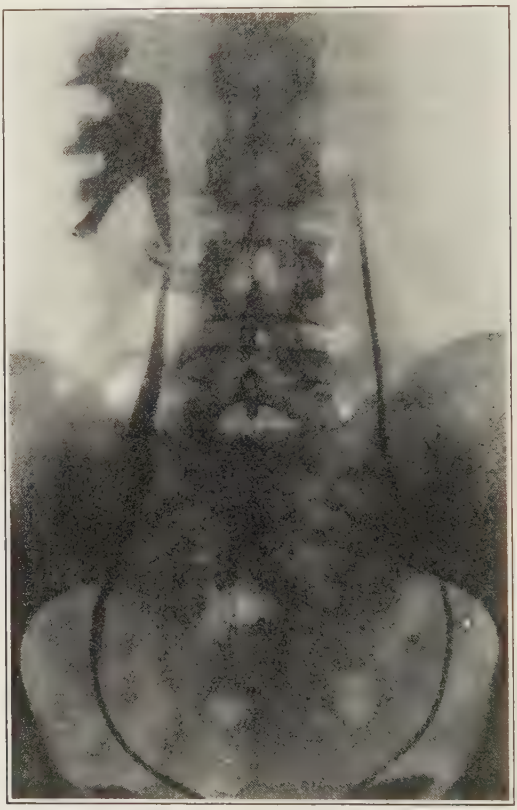


FIG. 167.—Kink and stricture of the right ureter. This is the first of a series of patients referred to the urological department by Dr. Eugene Pool's follow-up clinic. These cases were all patients who had been operated upon for right-sided pain by appendicectomy, without relief of symptoms. Every one of the series had some right ureteral pathology, and in practically every case it was of sufficient degree to account for the symptoms complained of. The pain from which this patient suffered was entirely relieved by applying a suitable belt to elevate the kidney, and dilating the ureter with bougies of increasing size.

ing elevation and valvulation of the ureteral orifice, a plastic operation is almost sure to be necessary to restore any approach to normal conditions.

A free oblique incision, such as is used for nephrectomy, will give the best exposure of the renal pelvis and the ureter, thus permitting the recognition of even a very small aberrant vessel. If the infection

is not extensive and no hydronephrosis has occurred, it will be sufficient merely to divide the vessel and do a nephropexy. But if a large hydronephrosis is present, it is better to do a nephrostomy after the vessel is cut, leaving a drainage tube in place for a short time. It requires very nice judgment to select the vessel which is causing the trouble and to judge of the wisdom of severing it. A large vessel going to the lower pole of the kidney should never be cut unless it can proved beyond a doubt that it is causing obstruction. There is always danger of necrosis of the kidney following the severing of this source of blood supply.

Kinks of the Ureter.—Kinks of the ureter or sharp and abnormal curves, are found in males and females alike, and although it is possible for them to occur in any part of the duct, are most likely to be seen in the upper third. As has already been noted, such kinks can only be demonstrated by the injection of an opaque medium, and before taking the final pyelogram, the ureteral catheter must be withdrawn to a point well down in the bony pelvis, after which a separate injection of the ureter must be made. Observations at operation and necropsy suggest that two factors are mainly responsible for the occurrence of kinks; chiefly, undue mobility of the kidney, especially lack of support of the ureter as regards its lateral motions, and weakness or herniation of its normal sheath.[44]

Tubercular Strictures.—If much pus be present in the urine and the examiner finds a constriction of the ureter which is perhaps impassable, but not necessarily impermeable, he may have reason to suspect a genito-urinary tubercular infection. No matter whether an acid-fast bacillus can be demonstrated or not, if an early cystoscopy is done and impassable ureteral obstruction encountered, and if purulent urine in which no organisms can be demonstrated is issuing from the kidney, the probability of tuberculosis is very great.[23]

Focal Infection.—By far the largest number of ureteral strictures are undoubtedly of infectious origin, and while tuberculosis, gonorrhea, and to a less degree, syphilis, are surely responsible in a certain percentage of cases, it is much more likely that simple chronic stricture most frequently has its origin in focal infection carried to the walls of the ureter from some point relatively remote, such as diseased tonsils, teeth, sinuses or gastro-intestinal tract.[31] As this infection is blood-borne, the finding of organisms in the urine will be secondary to the stasis produced by the stricture. It may also travel by way of the lymphatics to the ureteral wall, passing upward from below, or sometimes through lymphatics which anastomose with those of the colon. It is possible for the infection to extend up along the mucous membrane of the ureter, although this rarely happens.

Pathology.—The pathology of these narrowings is similar to that of stricture in other ducts of similar structure, taking the form of connective-tissue proliferation and cicatricial contraction, all the coats of the wall being equally involved, and the lesion varying in character

from a simple annular narrowing to a markedly extensive area of dense infiltration. Involvement of the various coats begins with the lumen and gradually extends to the mucous coat, soon setting up ulceration, connective-tissue proliferation and subsequently contraction, which is a result of the action of the urine's chloride elements. The organisms most frequently demonstrated are gonococci, staphylococci, streptococci and the colon bacillus.[2]

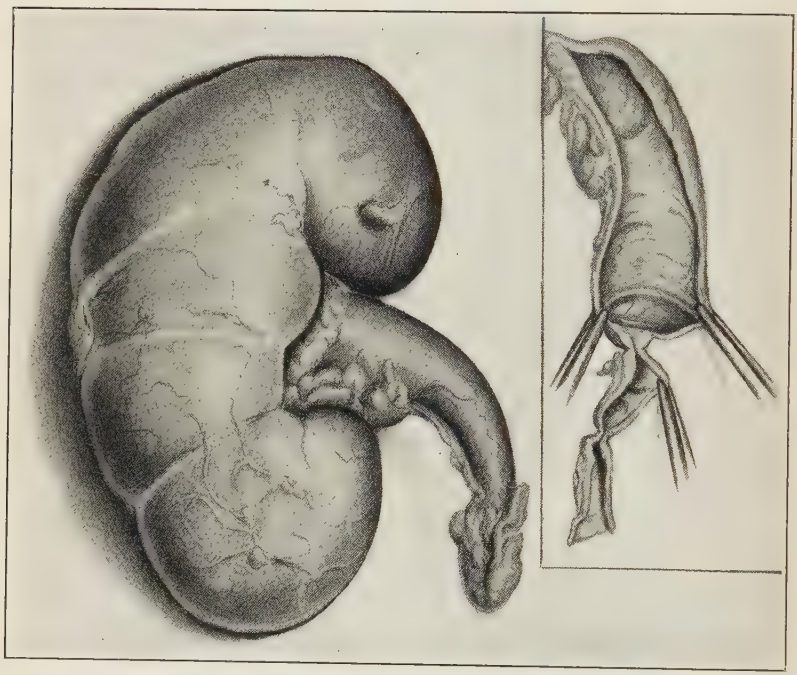


FIG. 168.—Strictures of the ureter. Specimen removed at autopsy, showing strictures of the ureter. The points of stricture are shown at the lower end of the ureter in the picture with dilated ureter and pelvis above. This is covered with an area of fat necrosis, adhesions, etc. The insert shows the ureter opened above and below the strictures. Above the narrowings the ureter is markedly dilated. Below there is slight widening of the canal. These strictures were not due to tuberculosis or any extraneous influence, the lesions being strictly confined to the area shown above in the insert.

Other causes of ureteral obstruction are the presence of calculi, which has been shown by Hunner to have a special relation to the existence of stricture, and will be elsewhere discussed; metastatic tumor implants which may be detected by observing tumor tissue in the urine or by pyelography; renal neoplasms and nephroptosis. Of course renal growths may be present without in any way obstructing the ureter. The diagnosis of stricture will depend upon the results of cystoscopy and pyelography more than upon anything else.

Diagnosis.—When a patient suffering from a ureteral stricture presents himself, or more often, *herself*, to the urologist, he will commonly

elicit a history of many vain attempts at operative relief. One patient mentioned in the literature several times had spent eighteen years of a life span of thirty-six years in hospitals, and had undergone 8 operations, 7 of them being laparotomies. Not infrequently symptoms due entirely to the lesion in the ureter are attributed to neighboring organs, and when a pathological condition exists not alone in the ureter but in the adjoining organs also, it is a very easy matter to focus the attention upon these neighboring viscera, and ignore the possibility of ureteral involvement entirely. Sometimes, even after the removal of the adjacent organs, or at least of the source of symptoms, the persisting ureteral difficulty will be attributed to postoperative adhesions for the relief of which still further operative procedures are often suggested and carried out.[49] The appendix, as may easily be imagined, is most frequently the scapegoat, with the female pelvic organs pressing it closely for second place, and in the male the rectum, colon, or perhaps the seminal vesicles or prostate, fall in line behind the appendix.

When there is continuous pain, or an "ache" which the patient locates at some definite point in the urinary tract; when there are intermittent attacks of severe pain in the lumbar or ureteral region with downward radiation toward the bladder and thigh, or more rarely, upward toward the kidney, with the frequent accompaniment of gastric disturbances, chills, etc.; when there are urinary irregularities such as frequency, dysuria and urgency bordering on incontinence; and finally, when urinalysis shows pus or blood, especially if the occurrence of these findings is irregular; then there is good reason to suspect a stricture of the ureter, and to proceed at once to a thorough cystoscopic and pyelographic examination.

Examination.—Palpation will be of service in revealing the tender spots which correspond to the stricture, for if the ureteritis is marked and extensive the entire ureter may be very sensitive. Vaginal or rectal examination will also reveal these tender areas in the inferior part of the ureter. If the ureter is so distended that it juts out into the bladder, the cystoscope will show a nipple-like formation with the ureteral orifice at its apex. Sometimes the mons ureteri will show only a bullous edema. The stricture may be so dense that several attempts will have to be made before the catheter can be passed into the ureter. Once the catheter is passed, the appearance of a steady stream of urine is very suggestive of hydronephrosis and stricture, as the normal passage of urine from the renal duct into the bladder is by single drops, at the rate of about seventeen to the minute. Extreme pain when the catheter passes the constricted point is also another strong indication of the existence of the lesion, and if there is free bleeding, it will likewise serve as confirmatory evidence.

Use of the Wax-tipped Catheter.—The most definite means of diagnosing a ureteral stricture is, however, the passage of the wax-tipped catheter. If, on attempting to remove it there is a definite "hang" and grating sensation as it passes the strictured area, or if it comes

through with a jump, the evidence is practically conclusive.[25] Careful pyelography will serve to correlate the findings and give suggestions as to remedial measures. As Walther[55] has very pointedly remarked the cystoscopist who feels that he can eliminate stricture simply because the ordinary-sized ureteral catheter easily transcends the ureter to the kidney, will frequently fall into error. Only repeated soundings, noting the same obstruction in the same location, can be depended upon to establish the diagnosis. Ureterograms, although of value at times, may mislead one. Sanes, however, is of a directly opposite belief, for he asserts that urography is the most valuable aid in the diagnosis of ureteral obstruction. The opaque fluid injected into the kidney and ureter gives us roentgenographic shadows which, if properly interpreted, supply us with valuable information which cannot be obtained by any other means.

Prevalence of Bilateral Ureteral Stricture.—There has recently been published by Hunner[30] a report on 100 cases of ureteral stricture in the female which he treated at least five years previously, and in this report we have some very enlightening observations on the relation which these strictures have been proved to bear to many heretofore unrecognized or misunderstood conditions, and also upon the most common location of such strictures according to his observations. One of his most interesting findings is that exactly one-half the patients had a bilateral stricture, a condition of affairs not hitherto noted as frequent. "In our early work," he says, "it was customary to examine for stricture only on the side presenting symptoms. It was soon found that after an interval of months or years many patients returned complaining of the side which had not been investigated. Not infrequently a patient whose symptoms had been confined to one side developed pain on the opposite side after the first investigation of the symptom-producing stricture and others began to complain of the formerly quiescent side during a series of treatments on the side first affected. Not infrequently a complete investigation reveals the more damaged kidney on the symptomless side. We have found the larger hydronephrosis on the side without symptoms. We have also found an unsuspected renal calculus on the symptomless side, even when it was absent on the side with symptoms. Not infrequently the side with symptoms may present a large hydronephrosis, and the symptomless side a smaller hydronephrosis, or a kidney pelvis smaller than normal, while repeated functional tests show that the side with symptoms is doing the major portion of the work."

The most frequent location of ureteral stricture in women was found to be in what may be considered the base of the broad ligament, or in immediate proximity to the glands about the uterine vessels, namely, at a distance of from 2 to 5 cm. above the orifice, in 60 instances on the right side and in 48 instances on the left, there being some duplication due to multiple stricture. The region from 7 to 11 cm. above the bladder is roughly in proximity to the glands of the anterior iliac

vessels, and in this region stricture was noted in 13 instances on the right and in 14 on the left side. It was this writer's experience that what he terms the old tradition, that stricture is most frequently to be found in the three points of anatomical narrowing mentioned in

Fig. 169.—Stricture of the left ureter, with dilatation of the ureter and kidney pelvis above the lesion. Near the site of the ureteral lesion a ragged shadow is made out in the original plates which is thought to be a calcified lymph gland. Apparently the periadenitis included the ureter, which was constricted by the adhesions accompanying the condition. Relief of symptoms promptly followed dilatation.

a preceding paragraph, has no foundation in fact, as he had seldom found a stricture at the pelvic brim and only a few within the bladder wall area. Those strictures which were found at the pelvi-ureteral junction, he attributed to the coexistence of a pyelitis, an infected

kidney harboring a stone, or in some cases to the fact that previous surgical intervention had been done on the kidney.

Calcified Glands.—Calcified glands are frequently found in the broad ligament in women suffering from stricture of the adjacent ureter, and when the strictured portion of the duct is in its abdominal part a roentgenogram made of that section of the abdomen will very likely show one of these calcified glands or perhaps a venous phlebolith. These findings are more probably due to a previously existing inflammation, than to the presence of a congenitally strictured area.

Spastic Obstruction of the Ureter.—Not infrequently the introduction of an instrument will be sufficient to induce a spastic condition which will prevent the passage of a ureteral catheter. It must be remembered that the output of urine by the kidney may be temporarily suspended, psychic causes alone sometimes bringing such a condition to pass, so that the ureter will be without moisture and temporarily collapsed upon itself. To pass a catheter into a ureter under these circumstances is a practical impossibility unless some lubricant is used, or sufficient time is allowed to elapse to permit the kidney to resume function.

When the obstruction is at the uretero-vesical valve there should always be a strong suspicion that it is spastic in nature. When the patient gives a history of typical ureteral colic, alternating from one side to the other, or bilateral, while the radiologic examination reveals nothing which indicates the presence of calculus, the possibility of a normal kidney being unable to excrete urine through a ureter temporarily blockaded by spasm should be kept in mind, for by so doing, exploratory operation could be many times avoided, and even some falsely accused kidneys saved for their possessors' benefit.

Etiology.—The causes operating to produce stricture of spasmodic origin are rather obscure. It has been suggested that the uretero-vesical opening may be congenitally strictured, so that ordinary action of the muscles surrounding it may be sufficient to occlude it upon occasion. In some cases where the bladder muscles show trabeculation, syphilitic lesions of the cord, or similar neuropathic causes may be instrumental in producing the spasm. Fatigue and nervous exhaustion may cause it, just as these influences induce spasm at the pylorus and elsewhere. The immediate factor in bringing on the attack may be irritation from the passage of infected urine, highly acid or alkaline conditions, or calculi.[27]

URETERAL CALCULUS.

Etiology.—Ureteral calculi may be considered as of two kinds; those which are formed in the kidney and thereafter expelled into its duct, and those which originate in the duct itself. Renal calculi are elsewhere considered (page 633). Concerning the causes which give rise to stone formation in the ureter there is still a wide variance of

opinion, but during the past few years the majority of urologists have come to accept the views of Hunner, first placed before the medical profession in 1917.[28] At the very beginning of this century, Rovsing the distinguished Danish surgeon, published in Germany his views on the etiology of ureteral stone.[47] While he recognized the probability of a calculus forming in the kidney and making its way downward, he believed that such concretions were also primary to

FIG. 170.—Eighteen stones removed from one ureter. These calculi were evidently formed in the calyces of the kidney and sudden dilatation of the ureter and kidney allowed them to become dislodged and passed into the enlarged ureter, whence they were removed by ureterotomy by the authors.

the ureter due to a stasis of the urine by a stricture, be it a congenital stricture or valve formation, or the result of tuberculosis or other process of suppuration and ulceration. Infection may be coincidentally present causing indurated urinary deposits which will in time encrust the inflamed organic elements. Rovsing regarded any outside influence which tended to lessen the lumen of the ureter or anything which inclined to produce internal stricture as favorable to the production of ureteral calculus. Hunner goes further than this and looks upon

stricture as an absolute prerequisite to the formation of stone in the duct itself. He says: "Except for the one factor of the intermittent gush of urine which tends to sweep away foreign material from the

FIG. 171.—Giant ureter. The great dilatation of the ureter and thickening of the wall gave one the impression that the viscus was diseased intestine. The stone lodged just outside the intramural portion of the ureter and there is every evidence that it had been there for a great length of time. This case occurred on the service of Dr. Alfred T. Osgood and it is used here with his permission.

ureteral lumen, a ureteral stricture presents the ideal conditions for the formation of calculus. The strength of the normal gush must be increased in the narrowed stricture area, and yet there must be some

FIG. 172.—(Osgood's case.) The giant ureter is here shown opened wide. The stone completely fills the ureter. Extending upward from the main mass of the calculus is a small spur-like projection. The ureter below the pouch containing the calculus was extremely narrow.

interruption and eddying of the stream in some cases, thus making a degree of stasis favorable to stone formation. Our histological studies of the stricture area have shown a change in the type of epithelium from the transitional to the squamous, and that in some strictures

there is actual ulceration. The urinary analysis shows blood in a fairly large percentage of stricture cases. . . . A slight oozing and coagulation from a small blood clot at the stricture site would form an ideal nidus for the deposit of urinary salts, particularly with the added factor of stasis of the urine. Without actual ulceration of

FIG. 173.—(Osgood's case.) The stone is here shown removed from the ureter.

the strictured mucosa, we probably have other factors favoring stone formation, such as an excess of serous or mucoid secretion as found elsewhere in catarrhal conditions of the mucosa, an increase in the desquamation of the epithelium and irregularities of the surface to favor the retention of these organic exudates and the deposit of inor-

ganic precipitates." His general conclusion is that ureteral stricture plays a role in stone formation of far greater importance than has been realized heretofore. The majority of ureteral stones probably form within a stricture area. Some of these escape and give rise to bladder stones, or are passed. Some stones found in a strictured area probably escape and float upward and become kidney stones.

Symptoms and Diagnosis.—There is no doubt that stones may arise or lodge in the ureter and remain undetected for long periods, producing no symptoms that can be referred to the point where they are concealed. As will be readily understood, however, from what has already been said concerning stricture, symptoms which are actually due to ureteral disturbance are often ascribed to other parts of the urinary tract, or very likely to unrelated abdominal organs, such as the appendix or gall-bladder. If the stone has formed within a strictured area it may cause no obstructive symptoms on its own account, those present being traceable to the existence of the stricture, for the urine frequently grooves a channel alongside the stone, so that the urine is not held back, and it is only when circumstances arise which cause a change in the position of the calculus so that it blocks the ureteral lumen, and quickly produces renal colic and hydronephrosis, that its presence may become manifest.

Pain due to ureteral calculus arises from one of two conditions; intrarenal tension as a result of urinary obstruction or the existence of localized infectious changes.[8]

In a series of 654 cases seen at the Mayo Clinic, pain was referred largely to the upper renal area in 197 cases (67 per cent); to the upper abdominal quadrant in 45 cases (15 per cent); to the region of the lower ureter in 28 (9 per cent) and to the suprapubic area in 3 instances. No definite radiation of pain was reported in 16 cases and no pain whatever in 5 cases. The reporters' comment upon this classification is that it is evident that incision over any of the areas indicated, or even roentgenograms would almost always fail to include the actual site of the lesion. Renal colic is probably produced more often by ureteral stones than by kidney stones. When the pain is located by the patient in the lower abdominal quadrant it is usually because ulcerative changes have taken place in the ureteral wall, followed by periureteritis. This would be particularly true if the pain, previously periodic, became continuous over a period of a week or more. A history therefore, of previous colic referred to the renal area with subsequent pain localized to the lower ureteral quadrant would be suggestive of an impacted ureteral calculus with periureteritis.

It is not often possible to palpate the stone, unless it is a large one, and the indications of its presence which may be obtained from examination of the urine, do not give any valuable data for the establishment of a diagnosis. The methods which serve for the detection of stricture will have to be depended upon here as well, so that it is on the findings of roentgenography and pyelography, with the additional

information obtained from the wax-tipped bougie that the final decision must rest. One of the best methods of determining whether a shadow is in the ureter, in front of it, or behind it is the double exposure method suggested by Kretschmer. If the stone is in the ureter in

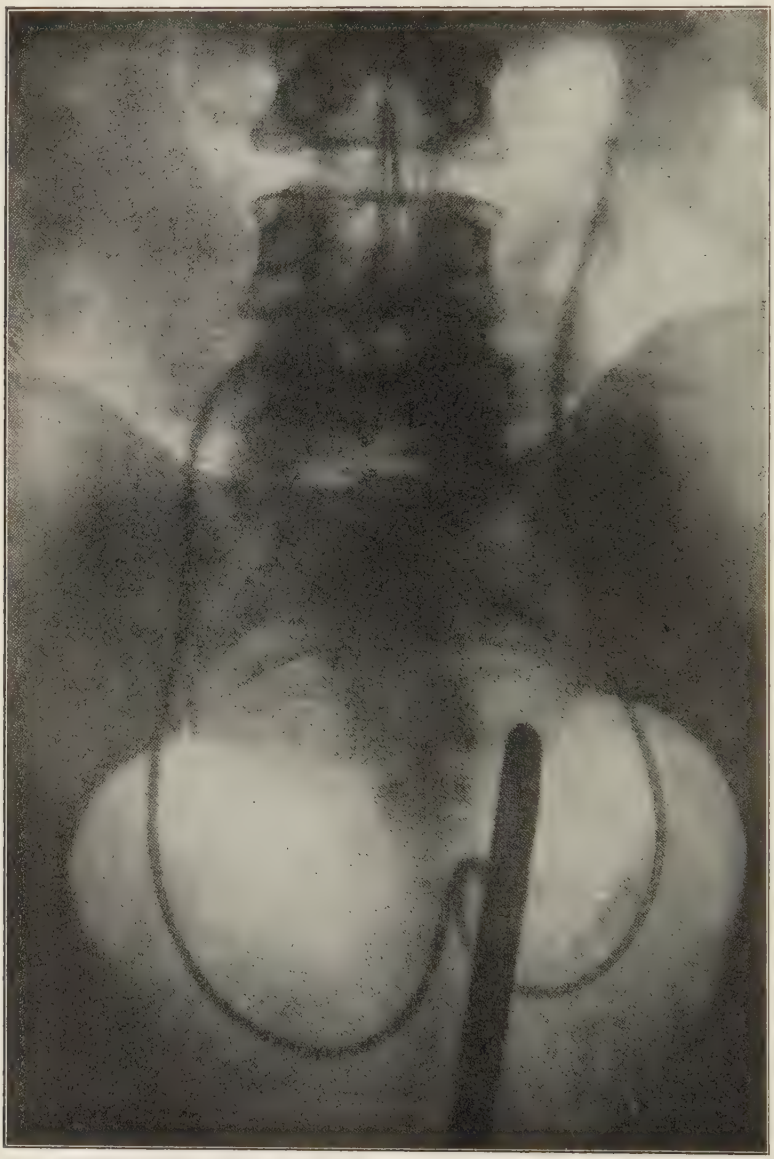


FIG. 174.—Stone in lower portion of left ureter, about as large as a small Spanish olive seed. This caused great local and general disturbance. It was finally passed, following dilatation of the ureter below the obstruction.

contact with the lead catheter, it will retain the same relationship to it when the tube of the *x*-ray machine is moved in making the second exposure, as it showed in the first one made on the same plate.

FIG. 175.—Wax-tip catheter showing a typical scratch from contact with a stone in the ureter. This method is of inestimable value in detecting the presence of uric acid or other non-shadow casting calculi, in either ureter or kidney.

TUMORS OF THE URETER.

Neoplasms of any sort are a very infrequent finding in the ureter. In an article on this subject compiled some four years ago,[1] reports of 47 cases found in the literature were included, of which 21 were papillomata, 12 were primary carcinomata and 14 non-papillary carcinomata, 4 of these last being of the squamous-cell type. Judd and Struthers, writing in 1921,[34] were able to collect but 25 cases of malignant tumor beside their own.

Benign Tumors.—Benign tumors of the ureter are very seldom encountered, but when seen, their structure will be found similar to that of epithelial neoplasms in other parts of the genito-urinary tract. Most frequently the papillomata will be multiple, and, as is the case with growths of a similar nature found in the bladder, while in themselves benign, they may induce malignant recurrence and metastases which are rapidly fatal.

Papillomata. Ureteral papillomata have been found in one or more of the three following places:[18] The entire ureter may be involved with the pelvis and bladder; the pelvis and only the first few centimeters of the ureter may be involved; or the growth may lie in the lower part of the pelvis and the upper part of the ureter, and also in the last few centimeters of the lower ureter, while the intervening part will be free from invasion. In all cases the visible tumor is due to the resulting hydronephrosis or hematonephrosis, and not to the neoplasm itself. Hematuria will often be the only clinical sign, but if pain is present it will either be of the sort usually associated with intrapelvic pressure, or of the "colicky" type, radiating along the course of the ureter, and probably due to the passage of clotted blood. Frequency of urination has also been reported in some cases.

Malignant Tumors.—Carcinoma.—Carcinoma of the ureter is a very rare occurrence. Crance and Knickerbocker[15] in connection with their own case found only 28 authentic cases in the literature, to which must be added the case published by Kretschmer, in 1924,[35] which brings the entire number of primary ureteral carcinomas so far reported to a total of 30 cases.

Symptoms.—Symptoms are similar to those manifested by renal carcinoma, hematuria being the most noticeable, while pain may or may not be present. In some cases there will be a visible tumor when hydronephrosis has become established. The hematuria generally appears without any apparent cause; the blood is profuse and thoroughly mixed with the urine. Clot formation will cause intense pain when the clots are passed, and there is likely to be an accompanying disturbance of vesical function which will be noticeable in frequency and urgency. The clots passed are, according to Judd,[38] very characteristic. They have the appearance of angle worms and sometimes are of great length.

Diagnosis.—The diagnosis, as in so many urinary new-growths, is a matter of considerable difficulty. Often only the most thorough going-over of the entire urinary tract will serve to give even a hint of the real source of the apparently trivial symptoms. The fact that blood in the urine is often the only sign until the lesion is far advanced is one more argument, if any more can possibly be needed, against the folly of falling back upon a diagnosis of essential hematuria until every possible means of discovering the lesion which is causing the appearance of blood, has been exhausted. If we wait until other more definite indications present themselves, the patient may be already beyond the reach of any ministration of ours. Other causes of ureteral obstruction will have to be ruled out; stricture, tuberculous or otherwise, and impacted calculus. If there is the slightest reason to suspect malignancy, instrumentation should be employed only with the utmost caution. Often when the bleeding has subsided, the passage of a ureteral catheter will start it up again, and this readiness to bleed on the slightest trauma, should be taken as strengthening the suspicion

of carcinoma. But very often, to judge by the meager literature at our command, there is no possibility of accurate preoperative diagnosis.

DIVERTICULITIS.

Dilatation of the ureter, both subsequent to obstruction and arising from other causes, has been divided into four types; obstructive, inflammatory, atonic and normal.[23] In the male, dilatations of the first class will be observed where such congenital anomalies are present as phimosis, small external meatus, urethral stricture, valve formation in the posterior urethra, or bar formation at the vesical neck; also in acquired urethral strictures, prostatic growths and large calculi or neoplasms in the bladder. In the primarily obstructive dilatations the observations possible by means of pyelography as now practiced, will usually show that the distorted ureter has a regular outline throughout, except at the point where it passes through the bladder wall, this being due, no doubt, to the resistance offered by the muscles at this particular junction. If a congenital anomaly exists, the results of pyelography should enable one to make a diagnosis without much chance of error. If, on the other hand, urinalysis reveals infection, we are probably dealing with an inflammatory dilatation, this usually meaning a diverticulitis which may or may not be secondary to a primary obstructive dilatation. Even when prostatic hypertrophy or pyelonephritis can be demonstrated, the dilated ureter and infected urine may be secondary to those conditions.

Diagnosis.—Diverticulitis is often hard to diagnose. Frequently the examiner will have great difficulty in deciding whether the dilatation which is revealed by the uretero-pyelogram was of inflammatory origin, or whether the pocket with its existing inflammation was not secondary to a mechanical obstruction. Calculi are frequently found impacted in a diverticulum, and their origin may have a bearing on the etiology of the inflammation. These etiological distinctions may perhaps be of little practical importance but the mode of infection may have an important bearing upon the conduct of the case, and should enlist the examiner's best efforts to ascertain it.

Atonic dilatation occurs at times in those cases of tabes dorsalis in which the bladder is involved. Injection with opaque media and radiography will show that the ureter is uniformly dilated, often on both sides, and in the accounts of the appearance in reported cases, mention is made that the vesical orifice also appeared cystoscopically to be dilated.

Normal dilatation should always be taken into consideration and due allowance made for it; otherwise some mistakes in diagnosis are likely to occur. Even when pyelography reveals quite marked dilatation, this alone should not be allowed to have too great weight in summing up the clinical findings. Changes in the ureteral wall, loss of elasticity due to dilatation and so forth, will of course, favor the

formation of diverticula and their subsequent inflammation, and in those numerous cases where stone formation is the result of stricture, the impaction of such stones and formation of such diverticula, with subsequent infection of the site of impaction, must occur more frequently than reported instances would lead us to suppose.

SURGERY OF THE URETERS.

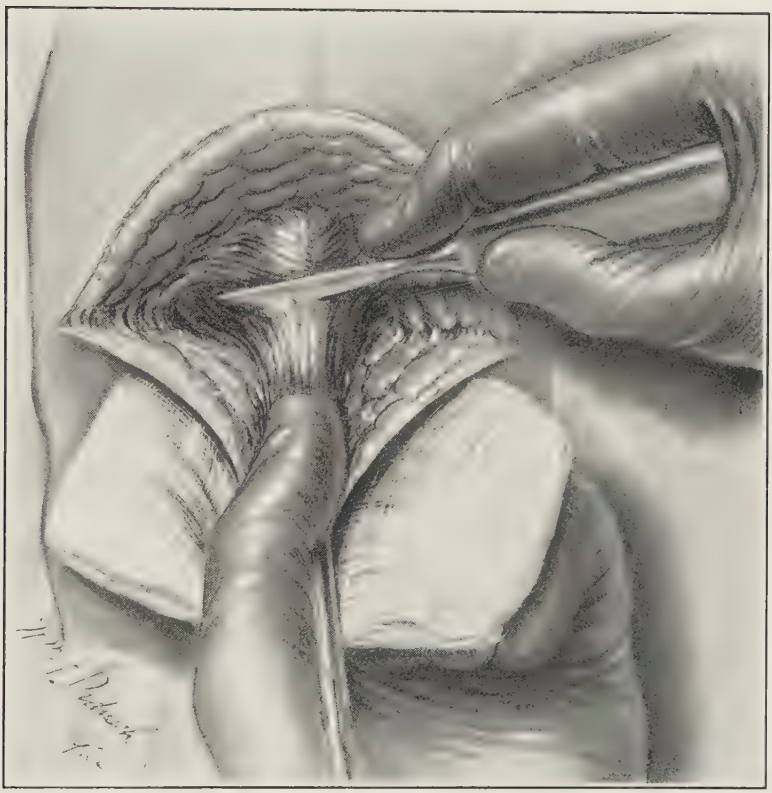
As any extensive intervention upon the kidney must, directly or indirectly, involve its ureter, much which concerns the surgery of the duct connecting the kidney with the bladder, finds a logical place for its discussion in the chapters relating to these two more important organs. But as ureteral surgery is still a matter upon which there is a wide variation of opinion among the foremost urological surgeons, there are one or two procedures which are deserving of separate discussion.

Complete Excision in Renal Tuberculosis.—Although the majority of operators do not attempt to remove the entire ureter when extirpating a tuberculous kidney, trusting that when the main focus of infection has been removed the lesser lesions will heal spontaneously, there are many circumstances where the complete excision of the duct becomes imperative. There is much to be said in favor of the pronouncement of Jones[33] who holds that from the fact that in the majority of cases the lower end of the ureter is so markedly involved, and also from the fact that partial removal of the ureter sometimes leaves a persistent sinus in the loin (which in one of his patients led to the formation of an intractable fecal fistula, eighteen months after the removal of the kidney), one is almost forced to the conclusion that it would be wise to remove the ureter completely with the kidney whenever the general condition of the patient warrants the prolongation of the operation.

A good many years ago Lilienthal[38] called especial attention to what he termed the "strange unwillingness" of surgeons to completely remove a ureter known to be diseased, at the same time with its kidney, and asserted that he personally, was convinced of the necessity for the removal of every diseased duct. By prolonging the time for doing the nephrectomy not more than eight or ten minutes, he had found it possible to extirpate the ureter completely, his method being as follows:

After extra-peritoneal nephrectomy has been done by any of the approved methods, with separate tying of the ureter and bloodvessels, the ureter is severed between two ligatures or clamps and the mucous membrane of the stump cauterized, using 95 per cent phenol. The ureter is drawn out of the wound, or if this is not possible, isolated by gauze, and the clamp being removed, a good-sized flexible *urethral* bougie with conical or olive tip, is passed down toward the bladder. A ligature is tied tightly around the ureter and its contained instrument,

PLATE X



Dissection of Perineum.

The central tendon is incised behind the insertion of the transverse perineal muscles. This is important, as it allows them to be retracted ventrally with the bulb, following which the rectourethralis muscle is seen and incised, exposing the apex of the prostate. Great care is taken to keep entirely away from the membranous urethra as a disturbance of its wall or surrounding musculature may result in incontinence. The finger is kept in the rectum during the dissection. It aids materially in the rapidity and safety of the procedure.

PLATE XI

FIG. 1

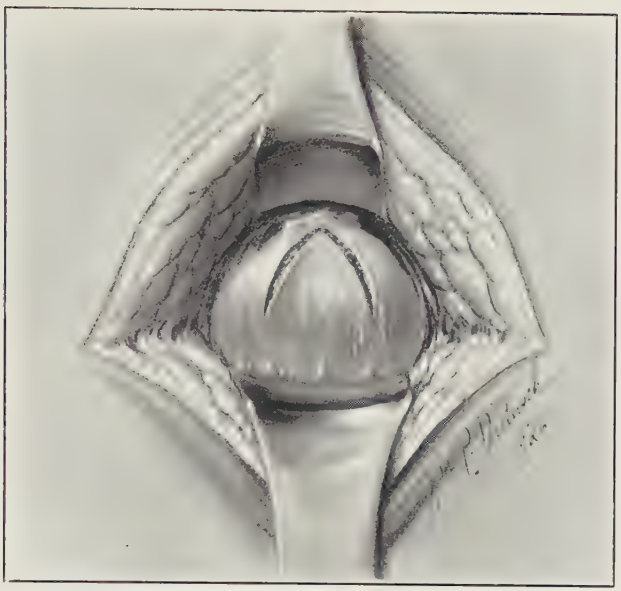
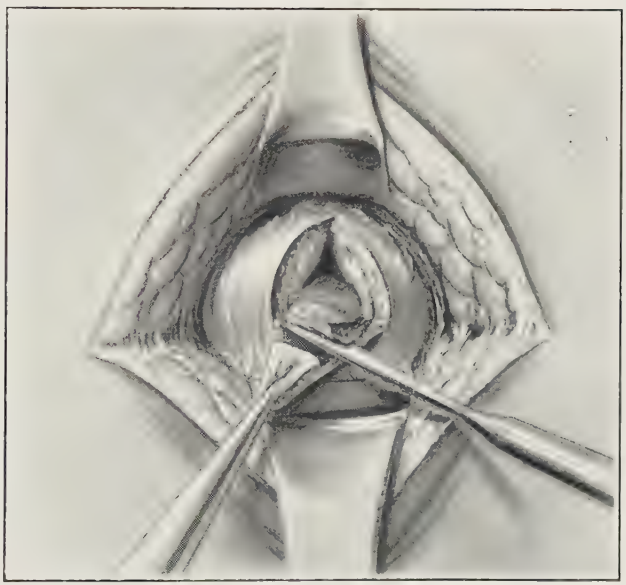


FIG. 2



Incision and Enucleation of Prostate.

FIG. 1.—The levator ani muscle is separated from the posterior surface of the prostate and retracted laterally and posteriorly. A tongue-shaped incision is then made through the fascia of Denonvillier, capsule of the prostate, posterior and middle lobes of the prostate into the prostatic urethra.

FIG. 2.—The tongue-shaped piece of tissue is drawn back and grasped with the forceps just above the verumontanum. It is cut across and the incision extended down in front of the lamella of tissue which separates the posterior lobe from the remaining lobes of the prostate and which contains incorporated in it the ejaculatory ducts. Thus we see the normal orifices of the ejaculatory ducts and their natural course through the prostate are retained intact. After removal of the middle, right and left lateral lobes, anterior lobe, if one persists, and the subcervical group, if enlarged, the cavity is packed with gauze and the tongue of tissue is allowed to be pushed back into place by the rectum. The careful preservation of the verumontanum and ejaculatory ducts is justified by the lessened amount of epididymitis seen since this method has been in vogue at the Brady Foundation, New York Hospital.

so as to hold the bougie in place and prevent the leakage of infected fluids from the canal. The lumbar wound is closed about a drain, the patient put in the dorsal position and incision made about 1 inch from the median line toward the anterior-superior spine of the ilium. This incision from $1\frac{1}{2}$ to 3 inches in length, depending upon the thickness of the abdominal wall, is carried rapidly through the abdominal muscles to the peritoneum, whence the gloved finger can easily work its way downward to the ureter, until it comes in contact with the characteristic feel of the contained bougie. The finger then separates the ureter and draws it and the bougie within it, out from the wound; an assistant withdraws the bougie from the nephrectomy wound and tightens the ligature. The upper portion of the ureter is brought out through the nephrectomy wound by a gentle pull, and it may be then ligated firmly and severed, the mucosa being cauterized with phenol.

If desired, during the latter part of the procedure, the foot of the table may be raised and the depths of the wound exposed by retractors, so that the work can be completed under direct vision. Careful supervision of the drainage is very important, as a rubber tube left in the wound for any length of time, might induce ulceration of the great iliac vessels, so as to cause sudden and fatal hemorrhage. Only gauze or other soft dressing should be used.

Complete Ureterectomy in Women.—Complete ureterectomy in women is frequently performed according to the practice of Bovée[7] whose technic is as follows: An incision is made through the anterior vaginal wall to the ureter, which is loosened at its point of entrance into the broad ligament, ligated next to the bladder and cut across. A loin incision is next made, about 5 inches in length, running from the end of the false ribs toward the right anterior-superior spinous process. Through this the kidney and ureter are separated to the brim of the pelvis, the vessels clamped, severed and tied, and the kidney and upper section of the ureter removed. If it is necessary to make openings in the peritoneum, they are immediately sutured. The remainder of the ureter is then dissected from above downward and removed, and gauze drainage left in both wounds.

Ureterotomy for Stone.—Operations for the removal of stone in the ureter are becoming less frequent as the technique for the removal of stone in the ureter by the urological surgeon is improved. The criteria for open operation are: (1) Stone accompanied by persistent high fever unrelieved by ureteral manipulation; (2) ungovernable pain over a long period of time; (3) failure of all methods to move stone after many attempts.

The rectus incision is used for middle and upper ureter stone. The Gibson golf stick incision is useful in middle and lower ureteral operations. The Lowsley perineal approach is suitable for impacted stone in the terminal portion of the ureter.

Removal of Calculus Through the Perineum.—It has been our experience that many stones lodged in the terminal inch of the male

ureter are more easily extracted through the perineum than by the customary abdominal route. With the patient in the exaggerated lithotomy position, and a sound in the urethra to serve as a guide, a horseshoe-shaped perineal incision is made, with the curve above the bulbous portion of the urethra and the ends well to each side of the rectum. The incision is carried down through the central tendon, keeping close to the urethra, as far as the apex of the prostate. At this point the recto-urethralis muscle must be incised so as to avoid

Fig. 176.—"Gibson Golf Stick" incision for stone in the middle or lower ureter.

tearing into the rectum, an accident very likely to occur should blunt dissection be attempted (Fig. 180). Separating the levator ani muscle from the prostate, avoiding the rectum by continued dissection upon the genito-urinary organs, the posterior surface of the prostate is exposed, this gland being easily recognized by the glistening fascia of Denonvilliers in which it is enveloped. The sound is withdrawn from the urethra and a blunt-tooth retractor fixed at the base of the prostate (Fig. 179) upon which sufficient traction is exerted to draw forward the prostate and seminal vesicles. It is well at this time, to elevate the

foot of the table considerably, as the wound is quite deep and the ureter is on the roof of the wound. The intervesicular fascia (page 576) is then incised and drawn laterally, exposing the ampulla of the vas and the seminal vesicle on the side of operation. With the rectum held down by a long curve-backed retractor (Fig. 179) the dissection is carried still deeper, until the ureter is exposed at the point where it

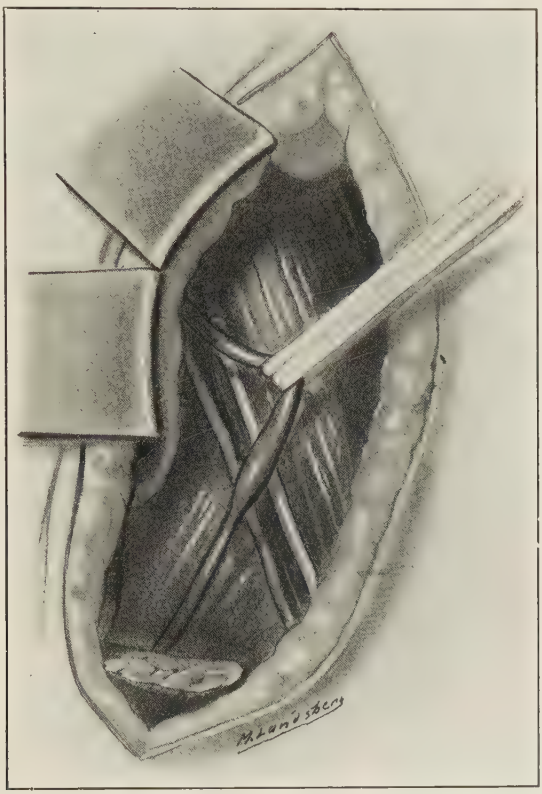


FIG. 177.—The rectus muscle is sometimes cut partially across to allow a more satisfactory approach to this deep-lying structure. The ureter is usually found clinging tightly to the peritoneum. It is much more easily identified if the precaution is taken previous to operation of introducing a catheter through the cystoscope. The stone is easily palpated and the ureter isolated. A tape is put around it for purposes of traction. This operation has on several occasions been successfully performed by the authors under regional anesthesia.

emerges just above the tip of the seminal vesicle. The vesicle is freed and slightly lifted and the other tissues surrounding the ureter dissected away from it. When isolated, a tape is, if possible, passed around it, beyond the point where the stone is located. A longitudinal incision made directly over the stone permits its removal with bulldog forceps. As it is practically impossible to set a suture in the ureter,

a cigarette drain is inserted at the point of incision, and the wound closed by drawing together the separated fibers of the levator ani muscle, making use of plain catgut sutures, the outer skin being closed with silkworm gut. During the first few days the dressing should be changed frequently, as there will be considerable leakage through the perineal wound. In order to hasten the healing of the ureteral wound a cystoscope may serve to pass a catheter to the ureter, where it can be left in position for a day or two. The fact that we can take advantage of natural downhill drainage from the incised ureter, permits no absorption of urine and avoids the concomitant infection which so

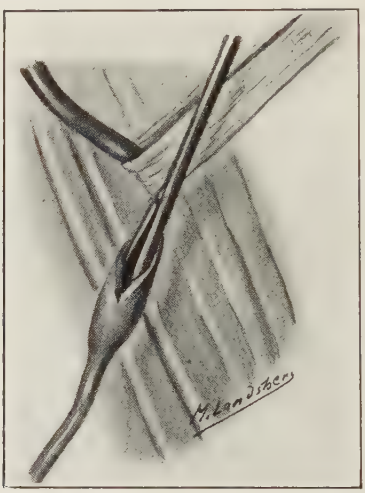


FIG. 178.—A linear incision is made into the lumen of the ureter and the stone milked up to this point. It is then removed with the bulldog forceps. The authors avoid suturing the ureter after removal of the stone, as it is felt that catgut stitches will harbor any infection that may be present. A cigarette drain is carried down to the point of incision to conduct the leakage that occurs to the outside. This is left in position for forty-eight hours. If leakage persists for any considerable period the patient is cystoscoped, and a large-sized catheter introduced beyond the point of incision. This procedure usually diverts the stream into the proper channels for all time. Every case which has an operation upon the ureter should have several dilatations to prevent stricture formation.

frequently accompanies urinary lithiasis, and leads to the formation of scar tissue, often later resulting in stricture. The perineal route is not applicable to fat patients, nor to movable stones. It should only be used in cases of stones impacted in the lower part of the ureter which have resisted all efforts by means of cystoscopic manipulation to move them.

Removal of Stone by the Vaginal Route.— For the removal of stones from the lower ureter in women, the employment of the vaginal route has lately been revived.[40] With the patient in the lithotomy position, the cervix is caught with a curved tenaculum and pulled well to the opposite side, which serves to draw down the base of the bladder and

the ureter. The stone is palpated and an incision made through the mucous membrane of the vagina, parallel to the ureter. The tip of the index finger is then pushed through this opening in the vaginal mucous membrane, and the ureter and its contained stone are located. In order to prevent the migration of the stone upward along the ureter,

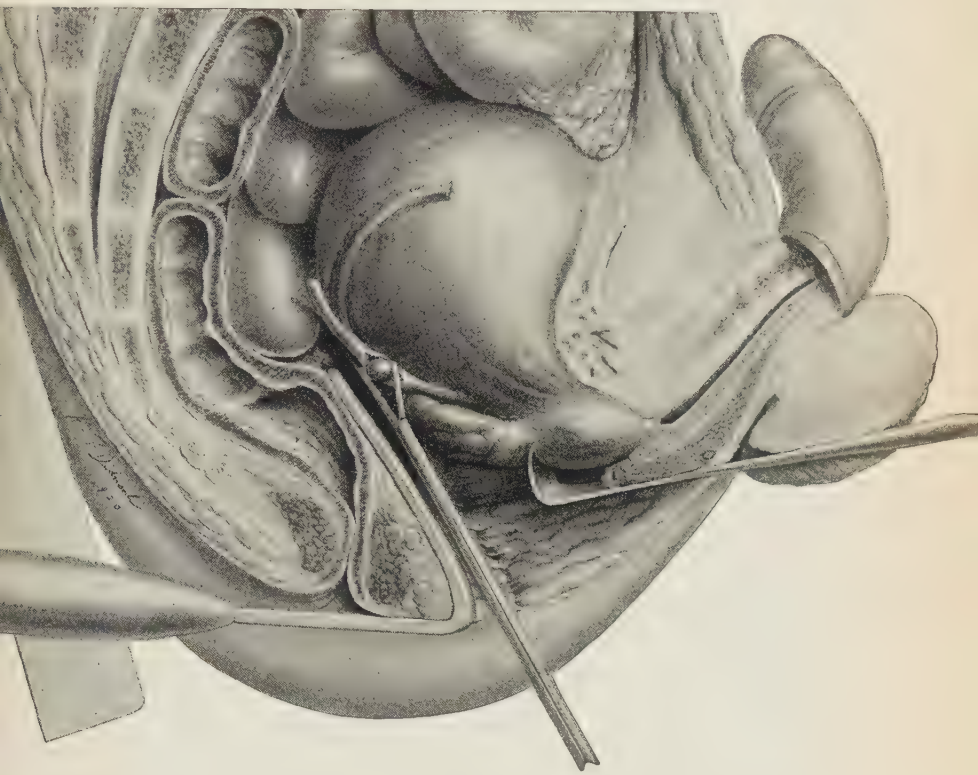


FIG. 179.—Lowsley's perineal operation for removal of stone impacted in the lower ureter in the male. Sagittal view showing the relations of the parts involved. The anterior retractor is shown grasping the base of the prostate pulling the seminal vesicle up into the perineal wound. The Crowell tractor is useful in this regard. The posterior retractor pushes the rectum out of the field. The ureter is noted dipping into the bladder wall just under the tip of the seminal vesicle. The forceps are shown grasping the stone through an incision into the ureteral lumen. The vas deferens passes around the ureter from a mesial position to a lateral one, finding its way through the inguinal canal to the epididymis and testicle.

a tenaculum is placed above it, and by releasing the traction on the cervix and exerting traction gently on the tenaculum, the ureter and its contained stone can be brought within the opening in the vaginal mucous membrane, and the stone easily extracted by making a longitudinal opening. After closing this incision, the ureter is released, a small cigarette drain inserted through the vaginal slit, and healing

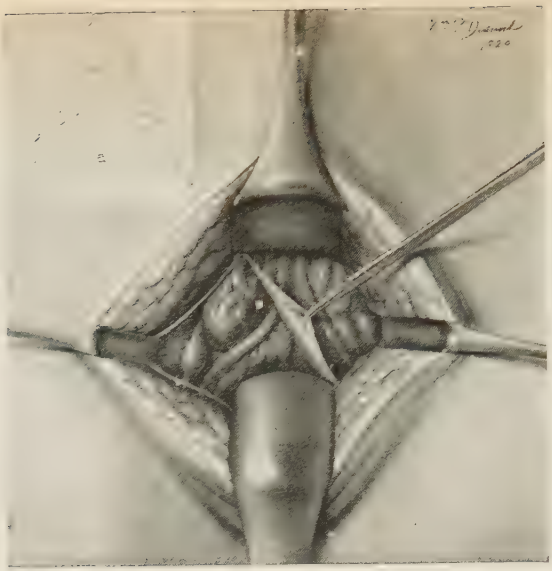


FIG. 18. — Lowsley's operation.) The fascial envelope covering the seminal vesicles is pressed and held aside. By dissection the ureter is exposed—the position of the calculus being indicated in the picture by the dotted line. The relations (posterior view) of the parts involved are shown in the insert.

FIG. 181.—(Lowsley's operation) The tip of the seminal vesicle is held aside disclosing the ureter with its contained stone. This is held in position by a tape so that it cannot slip up into the dilated ureter above.

is usually so prompt that the drain can be taken out at the end of the second day, and the patient be discharged in a couple of days more. Even if leakage of urine should occur there will be dependent drainage, so that healing will not be greatly delayed.

Operation for Stricture of the Ureter.—Operation for stricture of the ureter in those few cases where it is impossible or inexpedient to dilate it gradually, is usually performed in much the same manner as the removal of calculus. In general such intervention upon the ureter is to be avoided whenever possible. It must be remembered that the stricture is in itself cicatricial in nature and any surgery will tend toward the formation of more scar tissue, so that the end-results cannot offer any great improvement over the original condition. Dilatation over a long period must follow such procedure also, so anyone who is equipped with the proper instruments, and has acquired sufficient skill and judgment, will practically never have to resort to surgery.

Repair of Surgical Injuries.—When the ureter has been completely severed during the course of a surgical operation, the surgeon has several courses open to him. He may attempt an anastomosis, or may implant the severed end directly into the bladder, provided the ureter can be sufficiently extended to permit this. Many surgeons do not attempt to repair it at all, but by ligating the cut end, bring about hydronephrosis and eventually atrophy of the corresponding kidney.[41] Others even go so far as to do a nephrectomy without waiting for atrophy to take place. In general, however, the patient who has been subjected to an operation as severe as are all those where surgical injury to the ureter can occur, is in no condition to withstand the effects of additional surgical procedures, and only a very prompt implantation or anastomosis will be possible. A rapid method of implanting the ureter into the bladder is to split the proximal end as one would a dandelion stem, then carry the split end into an opening in the bladder by guide sutures, using two or three fine catgut sutures to make the joint more secure. Albarran's method, if the ureter is too short to reach the bladder, is to turn up a flap from the vesical wall, wrapping it around the end of the ureter, the opening in the bladder being then sewn up by a running suture. In order to avoid stricture at the point of implantation the following is suggested by Stoeckel: Instead of making a slit in the bladder, a round hole should be cut about the end of a clamp which has been inserted through the urethra into the bladder cavity, the mucous membrane and peritoneum being sewed together before the ureter is implanted.[24]

In operating for carcinoma of the cervix it is sometimes impossible to avoid cutting the ureter across its lower margin. When this happens the hysterectomy should be completed before any attempt to repair the ureter is made, for the surgeon will then have more room, and will be less likely to subject the duct to further injury.

Anastomosis.—The most common method of repair is either an end-to-end anastomosis or the end-to-side procedure. This may be accom-

plished by any of the well established methods, Van Hook, Poggi-Robson or Bovée's. Unfortunately, in the great majority of cases, an anastomosis will be found out of the question.

Implantation into the Bladder.—When the injury is too high up to permit of an anastomosis, the ureter is sometimes anchored to the skin of the lumbar region and a nephrectomy subsequently performed; or the proximal end is doubly ligated and allowed to remain in the abdomen. In the section on bladder resection (page 528) mention has been made of one method of implantation of the ureter; another suggested by Boari consists in cutting a strip of bladder wide enough to make a tube and long enough to connect with the end of the ureter above, then sewing the strip into the ureter and suturing up the gap in the bladder.

Transplantation of the Ureters.—The conditions which make it necessary to find new openings for the urinary ducts have all been touched upon in the foregoing pages. Beside the repair of accidents, the infrequent, but when found, exceptionally urgent condition of ectopia vesicæ, has been most satisfactorily relieved by making new outlets for the urine which enabled the patient to have its flow under voluntary control.

Choice of Site for Implantation.—In the past a large variety of sites have been selected for implantation, the loin, the groin, the vagina, urethra and chiefly the large intestine, have all had their advocates. It will be immediately apparent that voluntary control of the flow of urine can be attained only when the ureters are made to empty into the intestine, but the great drawback to such implantations has always been the danger of ascending infection. No particular success attended these attempts until a few years ago when Coffey[14] pointed out that success could only be attained by approximating as nearly as possible the normal route of the ureters through the bladder wall. He stated that the mechanical principle upon which the procedure rested was that the ureter shall be made to run immediately under the loose mucous membrane for a distance, before entering the lumen of the intestine.

History.—Attempts to relieve the incontinence due to ectopia vesicæ by transplantation of the ureters lagged considerably behind those which partook generally of the nature of plastic operations upon the abdominal wall, which, even if they succeeded in closing the defect, made it necessary for the subject to wear, for the rest of his life, some kind of mechanical contrivance for the collection of urine. The first ureteral transplantations were to the loin, and these, of course, did not serve in any way to prevent incontinence. The history of various other attempts has been reviewed by the Hutchinses.[32] Simon in 1852, connected a previously closed bladder with the rectum by making a uretero-rectal fistula. A like type of operation was done by Fowler in 1898, and this same year witnessed the attempt of Gersuny who separated a loop of ileum and, after reëstablishing the continuity of

the intestine, brought one end of the loop down through a tunnel made within the anal ring, and at a second operation transplanted the base of the bladder into the upper end of a short segment of the bowel within the peritoneum. Ten years later, in 1908, Drakonow drew a strip of bladder through the space tunnelled between the sphincter ani and the rectal mucosa, so that the anal sphincter closed the new urethra as well as the anus; while Berhoogen divided the ascending colon and the ileum near the ileo-cecal valve, after which he closed the four ends and completed the intestinal canal by a union of the transverse colon and ileum; the appendix was drawn through a perforation in the abdominal wall and catheters were passed into the opening for irrigation of the cecum; later, the base of the bladder with the ureter intact, was united with the cecum and emptied of urine at regular intervals by means of a catheter. The fact that the patients who underwent these operations both died, probably explains why the procedures did not attain any great amount of popularity.

It was found by Stevens[52] that altogether there were thirteen different methods of ureteral implantation which have been tried at different times with more or less success. At least nine of these planned to keep the ureteral orifices intact. Soubottim made a channel of the anterior rectal wall which was joined to the bladder above and controlled below by the sphincter ani. The edges of the remainder of the rectal wall were sutured, leaving this tube to continue the rectal functions, as it was, of course, still controlled by its sphincter. As a fatal outcome followed 1 out of every 4 of these operations, and failure means loss of control, not only of the urine, but of feces as well, the gravity of any such undertaking is at once evident.

Maydl made the first successful intraperitoneal transplantation of the trigone with the ureters intact. Many years later Moynihan accomplished the same result extraperitoneally, although it should be mentioned that Bergenheim had made a successful extraperitoneal transplantation of the ureters into the rectum soon after Maydl's work was published. Pozza carried out the same procedure in March 1897, and on this continent, George A. Peters, of Toronto, Canada, practiced it on July 5, 1899. It is, however, to Bergenheim that the credit of making the first extraperitoneal implantation of the intact ureters, with rosettes of bladder wall attached, by separate openings into the rectum, should be given.[10]

Comparison of Extra- and Intraperitoneal Methods.—An examination of the literature concerning these various methods brings out the fact that the Maydl procedure as generally employed, has a higher mortality and presents greater difficulties to the surgeon because of its complexity and the increased risk involved in opening the peritoneum. The mortality of the Maydl operation was reckoned by Hutchins as 28.1 per cent, while that following Bergenheim's method was only 15 per cent.

Maydl's Operation.—Maydl's operation has been variously modified by those who have more recently performed it. Primarily, it consists of a direct intraperitoneal implantation of the trigone, including both ureteral orifices into the wall of the rectum. Some operators dissect up the bladder from the peritoneum to half its extent, open the peritoneal cavity and carry an incision entirely around the wall, being careful to turn the surrounding mucous membrane of the urethra backward so that its nerves and bloodvessels will remain intact. They regard the pelvic colon, with its easily mobilized peritoneal covering, as a more suitable vehicle for an anastomosis of this sort, than the rectum, which lies beyond the peritoneum and is, moreover, fixed at its lower end. Edmons and Moynihan both regard the separation of the ureters as a very dangerous procedure, but others are equally insistant that the two ducts should be implanted as far apart as possible.

Bergenheim's Operation. — Bergenheim's operation consists of an independent extraperitoneal transplantation of the ureters into the rectum, with a rosette of bladder wall attached to each, the bladder being thereafter wholly extirpated. At the Mayo Clinic where a large number of bladders have come under operation, the procedure is carried out as follows: In addition to the customary preoperative preparation, the rectum is cleansed with great care. The ureter is divided about 1 inch from the bladder wall, the lower end is ligated and the peritoneum closed. At a point opposite the isolated ureter an incision is made through the outer coats of the bowel, and at the lower end a puncture is made through the mucosa, large enough to admit the ureter which is drawn through and fixed in place, the divided peritoneum and muscle of the intestine being then approximated over the ureter. The procedure is carried out in three stages. At the first stage one ureter is transplanted; about ten days later the second ureter is similarly treated, and by the third stage the bladder is enucleated and the short ends of ureter attached to it removed.

In any operation involving dissection of the ureters, the greatest technical skill is essential, and every precaution must be observed to avoid infection; the dissection should be carried so far that when the ducts are placed in their new position there will be no kinks or twists, and all tension will be avoided.

NON-OPERATIVE TREATMENT OF URETERAL PATHOLOGY.

The structure of the ureter is of such a character and its location is in a measure so inaccessible, that surgeons generally have improved the opportunities offered by the rapid improvement in the instruments available to urologists, to dilate and otherwise manipulate the ureter through the bladder, rather than resort to laparotomy which has in the past so frequently proved both dangerous and unsatisfactory, so that at present, non-operative measures are being more and more employed.

Extraction of Calculi by Non-operative Means. – It has quite recently been said by Braasch of the Mayo Clinic that in all probability the majority of stones in the ureter pass spontaneously and for this reason he advises that while no rule can be adopted, it would be rational in the great majority of cases to wait at least two or three months until Nature has made several attempts to dislodge the stone. This seems to us a somewhat too conservative manner of regarding this question. The pain of ureteral colic is one of the most excruciating which human beings are called upon to endure, and it would seem unwise to permit a patient to undergo repeated attacks of such pain, when it is now so well established that in the vast majority of cases, they can be relieved by intravesical manipulation.

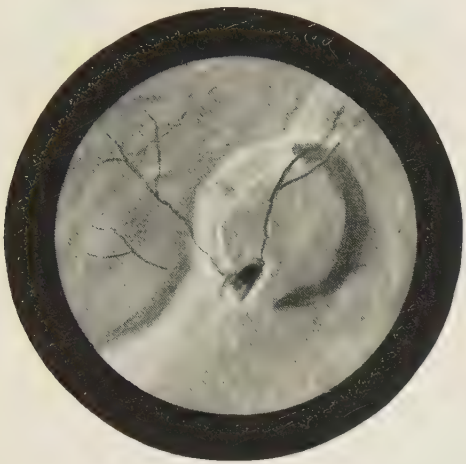


FIG. 182.—This figure shows a stone which has descended to the ureteral mouth. One recently seen by the authors was milked out of the orifice by gasping it with the Lowsley operating cystoscope. It was then removed from the bladder with the same instrument.

Ureteral Dilatation.—Ureteral dilatation is the most common and most successful method of extracting calculi. Sometimes a stone which has lodged in the upper ureter may be pushed upward into the pelvis by means of an olive-tip bougie, and the strictured section of the ureter which has prevented its further passage downward can then be dilated until the stone is able to descend all the way to the bladder without difficulty. According to Dourmashkin,[19] a stone thus pushed upward into the renal pelvis has a tendency to drop down to the site of original obstruction, so that the pushing up involves no danger of the stone failing to descend again. The usual practice is to dilate the lower part of the ureter at successive sittings until the stone finally enters the bladder, from which it can be removed with forceps or by crushing and washing out the fragments. Sometimes the forceps can be employed to remove a calculus from the ureter if repeated dilatation

has permitted it to descend to a point not far from the vesical opening. A good deal of fortitude on the part of both physician and patient is sometimes required to see this method of extraction through to a successful conclusion, but the patient can usually be persuaded to submit to the inconvenience of repeated cystoscopies if he understands that a laparotomy and protracted stay in the hospital can be thus avoided. As intra-ureteral manipulation can be carried out at the office, the expense of both time and money is far less than that which inevitably attends open operation.

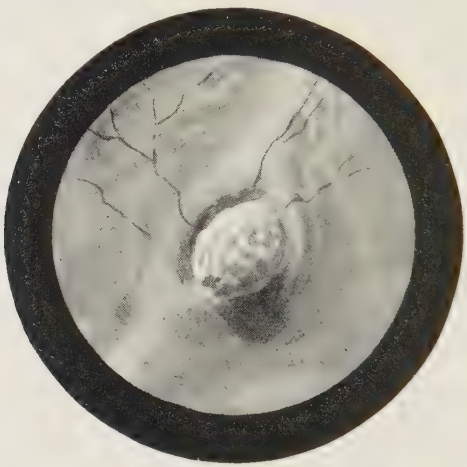


FIG. 183.—This stone presents its smaller portion through the ureteral orifice, being held back by the remainder, which had twice the diameter. This is not an infrequent finding as three of them have been seen during the past year at the Brady Foundation, in the New York Hospital. All were very easily removed with the Lowsley operating cystoscope very much as a dentist would pull a tooth.

Local Anesthesia and Oil Injection.—Local anesthesia and oil injection in conjunction with catheter manipulation and dilatation of the lower end of the ureter is another method which has been attended with success in the hands of many practitioners. At the Crowell Urological Clinic, 2 cc. of a 2 per cent solution of cocain is injected at the point where the stone is impacted, followed in the course of perhaps five minutes by an attempt to pass a catheter beyond the stone. This maneuver is usually possible after the anesthetic has relaxed the tissues, and thereafter 10 cc. of sterile olive oil is injected, and the patient put to bed, kept well under the influence of morphine, and given water in large quantities to stimulate the activity of the kidneys. If the patient is tolerant of instrumentation, the procedure is repeated after the lapse of two or three days, the size of the catheter being gradually increased. As large a size as 14-French may be used, but if the stone has not descended by the time the ureter has been dilated

enough to allow the entrance of an instrument of this size, the condition is regarded as surgical, and no further attempts to dislodge the stone by manipulation are made.[17]

Dilatation for Strictured Ureter.—The treatment of a strictured ureter follows the same general procedure as has been outlined for the removal of calculi, for in the majority of cases there will be a strictured area beyond which the stone is impacted. The gradual dilation of a stricture requires repeated instrumentation which some patients find difficult or even impossible to undergo. Patience, however, on the part of all concerned will usually be crowned with final success.

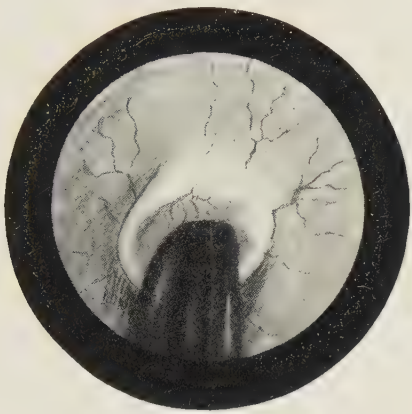


FIG. 184.—The authors prefer to dilate ureters by the multiple-bougie method. By using a specially constructed composite instrument it is possible to insert two No. 8 F., and one No. 9 F. bougies, making a total dilatation of 25 F., which is sufficient for all ordinary purposes. It is necessary to insert all of the small tips at one time in order to get these bougies started. The hydrostatic bag recently devised by Dourmashkin, of New York, promises to be a useful agent in dilating the ureter. It must be carefully used, however.

When the caliber of the narrowed lumen has been ascertained by means of wax-tipped or other bougies, the corresponding size of ureteral sound should be first introduced, and thereafter the larger sizes used in gradualy ascending scale, no more than two or three ever being applied at one sitting. The dilatability of different ureteral strictures varies greatly according to the virulence of the infection which was the original cause of the lesion, which influences the density of the scar tissue. The patient should be informed that the process is likely to be tedious and long-continued; otherwise the attendant may have some difficulty in making him persevere long enough to obtain a satisfactory result. Frequently the best results follow passing several ureteral bougies into the same ureter. This may be accomplished by using a specially constructed composite instrument. McCarthy's latest device is particularly useful in this procedure.

Irrigations and Other Palliative Treatment. What has already been said concerning the therapy of bladder diseases applies in general to treatment of the ureters also. Any treatment which is applicable to either bladder or kidneys must of necessity be shared by the connecting ducts (pages 532 and 675). The same is true as regards *diet*. When the ureter is in a highly irritative or inflamed condition it should be borne in mind that any diet which increases the urinary output places a greater burden upon the more or less crippled ducts, and these considerations should influence the regimen which may otherwise be desirable from the point of view of kidney or bladder pathology alone.

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CHAPTER XIV.

THE KIDNEY.

EMBRYOLOGY OF THE KIDNEY.

In discussing the embryology of other organs of the uro-genital system we have already seen how they all have their origin in the primitive uro-genital folds. The development of the human kidney must be followed through three phases, as three separate and distinct organs come into existence during the course of fetal life, the third and last only persisting as the permanent organ. These three glands as designated by embryologists are the pronephros, the mesonephros and the metanephros, this last developing into the kidney as it exists at term.

The Pronephros.—The pronephric tubules, which are the first anlage of the pronephros, arise from the primitive segment stalks found in the cavity of the fetal body. The pronephric tubules are made up of a principal tube associated with a pronephric chamber, a nephrostome canal and an external and internal glomerulus. The consolidation of the pronephric tubules forms a duct which extends the entire length of the fetal body cavity. This union takes place through a bending back of the tubules on each side, thus forming the *pronephric collecting duct.* Caudal to the fourteenth segment, no pronephric tubules are developed; the free end of the collecting duct, however, by a process of terminal growth, extends beneath the ectoderm in a caudal direction, though lateral to the nephrogenic cord, until it reaches and passes through the wall of the cloaca, thus forming the paired primary excretory, pronephric ducts. The pronephric tubules are found in embryos 1.7 mm. in length, where but nine or ten primitive segments are in evidence. In embryos having twenty-three segments, a length of 2.5 mm., all the tubules will have developed and united to form the primary excretory duct. When the embryo has attained a length of 4.3 mm. the duct will have reached and penetrated the cloacal-wall. These pronephric tubes degenerate very early, but the primary excretory duct persists and becomes the duct of the mesonephros.[4]

Origin of the Mesonephric Tubules.—Even as early as the period between the seventeenth and twenty-third day of intra-uterine life, it is possible to observe how the tubules which are to form the mesonephros originate from a cellular blastoma. This blastoma segments into rounded masses; these masses develop cavities that first unite with the cœlomic epithelium, then losing this connection, are joined to the Wolffian duct which already has definite enlargements. Finally

from a part of this tubule the thin-walled Bowman's capsule with its glomerulus takes its origin.[36]

The Mesonephros or Wolffian Body.—While the mesonephros resembles the pronephros in that it consists of a series of tubules each of which at one end is related to a knot of bloodvessels and at the other end opens into the primary excretory duct, it also differs from it in two important particulars. The glomerulus indents one end of the tubule and excreta from the blood pass directly into its lumen; and the nephrostomes are transitory and never open into the mesonephric chamber. Eight of these mesonephric tubules form before and behind, undergoing various metamorphoses in form as they develop, and finally reaching completion when the fetus has attained a length of approximately 9.5 mm. At this time thirty or more tubules will be in existence, each made up of a Malpighian corpuscle and a duct for secretion and for collection. Sometimes when the corpuscles are closely packed together, it will be observed that a single collecting duct may be the efferent duct of several tubules, and the mouths of several collecting ducts may also unite into a single orifice.

After the embryo has reached 10 mm. length rapid degeneration of the mesonephric tubules takes place. This degenerative process begins at the cranial portion and even while it is in progress, the formation of new tubules is going on in the caudal portion. Of 83 pairs of tubules, only 26 will be in evidence by the time the fetus has reached a length of 21 mm. and even in these a break will appear between their secretory and collecting portions.

Modification of the Excretory Duct.—A marked change in the primary excretory duct is also in evidence during the development of the mesonephros. Until the embryo has attained a length of 4.25 mm. this duct has no lumen, but thereafter traces of a lumen begin to appear; first at the ends, until at about 7 mm. length, the canal becomes patent throughout, so that there is free communication with the cloaca.

The *mesonephric arteries* originate when the embryo is about 5.3 mm. long. They have their origin at the lateral face of the aorta, whence they run into the Malpighian corpuscles, where they end in a rounding enlargement. Cranially, we may see a single artery in each segment, or even in two or three segments, but as we approach the caudal end the number of arteries increases, sometimes as many as four being found in a single lumbar segment. While some of these vessels degenerate, those originating between the sixteenth thoracic and the third lumbar segments remain, eventually becoming the phrenic, suprarenal, renal, accessory renal, internal spermatic and accessory spermatic arteries. They are also the origin of those branches which extend to the lymph nodes and the sympathetic ganglia which lie in the region between the superior and inferior mesenteric arteries.[31]

At 18 to 20 mm. length, in the angle which lies between the reproductive gland ventrally, the mesonephros laterally and the meta-

nephros dorsally, these arteries form a network, the *rete arteriosum urogenitale*. "From this network," says Felix, "which is remarkably coarse-meshed and composed of large vessels, the mesonephros, reproductive gland and metanephros are supplied with arterial branches, these organs being thus independent of single branches for their blood supply; should one or several roots degenerate, neighboring ones can take their places. The occurrence of this network at once explains why all persisting arteries that arise from the roots of this network show, within certain limits, a variability in the point of their origin from the aorta." Each renal artery takes its origin from a mesonephric artery. The kidney climbs upward to the mesonephric arteries, as if on a ladder; as soon as a sufficient blood supply is assured cranially, the caudal branches separate from it. When the kidney has acquired its definitive position it possesses several renal arteries, and of these one becomes greatly enlarged to form the definitive artery, while the others either degenerate or persist as accessory renals. The definite renal artery is either the last vessel of the second group, or the first of the third group. The relation of both groups, of the second to the suprarenal artery and of the third to the internal spermatic, explains the variation in which the renal artery arises from a suprarenal or from an internal spermatic; in the first case it may be a principal stem, in the latter only an accessory renal. The relations between the uro-genital rete and the metanephros show how the accessory renal arteries may develop, and explain their very varied relations to the kidney. Accessory renals from the first group will be branches of the superior suprarenal, and must pass over the dorsal surface of the kidney, and consequently they first reach the kidney on its dorsal surface and there penetrate its cortex. Those from the second group will be branches of either the middle or inferior suprarenal and will reach either the hilus of the kidney or the medial edge above this. Those from the third group may enter at the hilus, at the medial edge below it, or on the ventral surface of the caudal half of the organ. Should, exceptionally, a caudal branch be retained, it will be drawn upward by the migrations of the kidney, a condition that explains why such an artery may cross the principal stem or another accessory.

Importance of a Knowledge of the Renal Vessels.—The origin and development of the renal blood supply has been thus stressed because of its very important relation to renal surgery. The subject of anomalous bloodvessels in and about the kidney will be considered more in detail a little further on (page 597).

The Metanephros.—The permanent kidney, like the structure which precedes it, has a two-fold origin, as it arises in part from the mesonephric tubules, and in part from the isolated caudal end of the nephrogenic cord. Its chief parts are the renal corpuscles, which consist of glomeruli with their associated Bowman's capsules, and two sets of tubules, secretory and collecting. Following Felix, we may make an embryological division of this structure into a secretory or actual

glandular portion, and an efferent apparatus. The first of these has its beginning in a group of cells known as the metanephrogenic tissue, which envelops the primitive renal pelvis. This tissue originates in the metanephrogenic cord, a structure arising from the mesoderm. The cap which it forms is at first very thin, and is still further attenuated by the enlargement of the ureteral bud which forms the primitive pelvis. Cell multiplication is so rapid however, that the tissue soon becomes very dense, until it is finally stretched to such an extent that it is rent into as many fragments as there are tubules present. Thus are formed what has been termed a primary Malpighian pyramid, each ureteric tree with its metanephrogenic cap being regarded as a unit. The apices of the pyramids are called renal papillæ, and through them open papillary ducts. So closely are these pyramids packed together that their caps finally come to appear as if reunited into a single tissue enveloping the entire kidney. Thus arises the renal cortex.

Lobulation.—Beneath the various pyramids the lines of cleavage of the metanephrogenic tissue are marked by grooves, differentiating the space which each pyramid occupies, and this results in a certain amount of lobulation of the surface. From the primary pyramids secondary ones later develop, and this process is repeated so that the lobulation gradually becomes finer and finer. Between the pyramids, the renal columns of Bertini are formed by the dipping down of the cortex toward the pelvix. This fetal lobulation may persist into postuterine life, but normally the human kidney is not lobulated in the adult, as is the case with certain of the larger mammals.

Uriniferous Tubules.—It is from the compressed mass of metanephrogenic tissue that the uriniferous tubules take their origin. An eccentrically located lumen is opened up and the ball of cells thus transformed into a metanephric vesicle, from the peripheral wall of which the entire uriniferous tubule, excepting only Bowman's capsule, is formed. Bowman's capsule is formed from the central part of the vesicle wall.

Formation of the Ureter.—Between 4.5 mm. and 5.3 mm. length of the embryo the anlage of the ureter originates as a hemispherical outgrowth from the primary excretory duct. Though it at first grows in a dorsal direction toward the vetrebral column, as the embryo grows larger it tends to take on a flattened curve, so that in the later months the ureter develops in a cranial direction, and the dorsal surface of the mesonephros being thus attained, will be found lying in the retroperitoneum with an envelope of loose mesochyme about it. When the embryo has reached a length of 10 to 12 mm., the position of the renal pelvis will be definitely marked, radial outgrowths of the collecting tubules appearing at the level of the second lumbar segment. The formation of collecting tubules of the first order begins early in the process of development by an elongation of the primitive pelvis, a wedged-shaped enlargement of the anlage of the ureter, by which this

structure acquires its poles, these growing out in opposite directions. Later horizontal tubules, ventral and dorsal, develop, corresponding to the middle of the renal pelvis. The blind ends to the ampullæ of these four primitive tubules enlarge and from their ampullæ secondary collecting tubules grow out, which lie parallel to what will later on be the surface of the permanent kidney. These secondary tubules in their turn develop ampullæ from which a tertiary set of tubules is produced, the process continuing through the fourth month of gestation when, according to Arey, about twelve generations of tubules have been produced.

The pelvis and the primary and secondary tubules rapidly expand and enlarge. The two primary expansions become the *major calyces* and the secondary tubules opening into them form the *minor calyces*. In time the third and fourth generation of tubules become part of the walls of the secondary set; in this way the fifth generation comes to open as the papillary ducts, already described, into the minor calcyes. The tubules which are formed afterward persist as the *collecting tubules* found in the medulla of the permanent kidney.

The *development of the ureteric tree* follows somewhat the outlines of a fan, wide-spread and branching abundantly at the periphery, but much less prolific in the center. The pelvis later on absorbs some of the tubules which are compressed during the developmental process. When the fetus has reached a length of 10 mm. there will be the two pole lobules already spoken of in process of formation, and by the time it is 11.5 mm. long, anlagen of the central tubules will be discernible.

Bowman's Capsule.—Bowman's capsule, as has already been noted, develops from the central wall of the vesicle formed by the compression of the metanephric tissue. The anlage of Bowman's capsule at first appears as a sack attached to the young collecting tubule. The anlage of the uriniferous tubule anastomoses with the newly-formed collecting tubule so that they come to have a common lumen. The uriniferous tubule now assumes the shape of the letter S, connected above to the collecting tubule, and by its lower limb with Bowman's capsule. In passing it may be remarked, that one of the theories as to the origin of cystic kidney is that this anastomosis between the two types of tubules may fail to take place.

Origin of the Uriniferous Tubules.—The peculiar and definite structure and arrangement of the uriniferous tubules of the fully developed kidney are thus derived from this S-shaped analge. The slightly U-shaped middle limb of the S bulges into the concavity of Bowman's capsule which has been formed by differentiation of the lower portion of the lowest limb; the glomerulus is formed from the ingrowing arteries. The upper part of the lowest limb by enlargement, elongation and coiling becomes the proximal convoluted tubule. The primitive loop of Stoerck is formed from the lower part of the middle limb, while its base gives rise to the connecting piece, and the rest of it, with the upper limb of the S, comprises the distal convoluted tubule. In

the primitive loop of Stoerck a portion of the proximal convoluted tubule is included, as well as both the descending and ascending portions of what will be differentiated during the fourth fetal month as Henle's loop. At first the concavity of Bowman's capsule is shallow, but as development proceeds its walls grow over the knot of arterial loops from the glomerulus, leaving only an opening sufficient for the entrance and exit of the arterials.

The *capsule* is first distinctly differentiated only when the embryo has reached a length of approximately 70 mm. Though the anlage of the ureter and the outgrowing collecting tubules are initially surrounded by an envelope of connective tissue, the capsule cannot properly be designated as a separate tissue before the fetus has attained this length.

SURGICAL ANATOMY OF THE KIDNEY.

Position.—In the fully-developed adult, the kidneys will be found as two "bean-shaped" organs lying at the level of the lowest dorsal and the first two lumbar vertebræ. They are usually about 4 inches long by $2\frac{1}{2}$ inches in breadth, and something more than 1 inch in thickness. Normally, they occupy a position about 1 inch beyond the mid-line of the body, and from the back their location may be verified by ascertaining the point where the lowest rib approaches the spinal column, and thence mapping out a space 4 inches in a vertical direction, and $2\frac{1}{2}$ inches horizontally, beginning at the lower border of the eleventh rib, 1 inch beyond the mid-line. On the anterior aspect of the abdomen, a line drawn through the umbilicus will designate the lower border of the right kidney, but the left, which normally lies somewhat higher than the right, will be found above, in contact with the stomach, pancreas and certain sections of the intestines.

The kidneys do not lie directly backward and forward, for the oblique position of the psoas muscle and certain other abdominal structures which support the renal organs, causes their front aspect to look outward, so that they almost face the anterosuperior iliac spine. The right kidney, by virtue of its lower position, does not come in contact with the stomach, but is in relation posteriorly to the underside of the liver, and below this to the duodenum; while at its lowest part it touches other portions of the small intestine, as well as the hepatic flexure of the colon.

Fascial Envelope.—A layer of fatty tissue completely surrounds both kidneys, the amount and thickness of which varies greatly in different individuals. Outside this fatty layer will be found a capsule of fascia. The fatty envelope is almost wholly lacking in children and young subjects generally, hardly any trace of it being visible before the eleventh or twelfth year of life, but at any age the renal fat may be easily distinguished from other abdominal fat because of its finer texture and deeper yellow coloration. The perinephric fascia by which this fat layer is surrounded, finds an attachment on either

side to the spinal column; then passing outward behind the adipose capsule, is wound about the front of its respective kidney, and finally joins with the fascia from the opposite kidney in front of the great abdominal vessels and the spinal column. The fascia is attached to the diaphragm above, and its lower edge blends almost imperceptibly

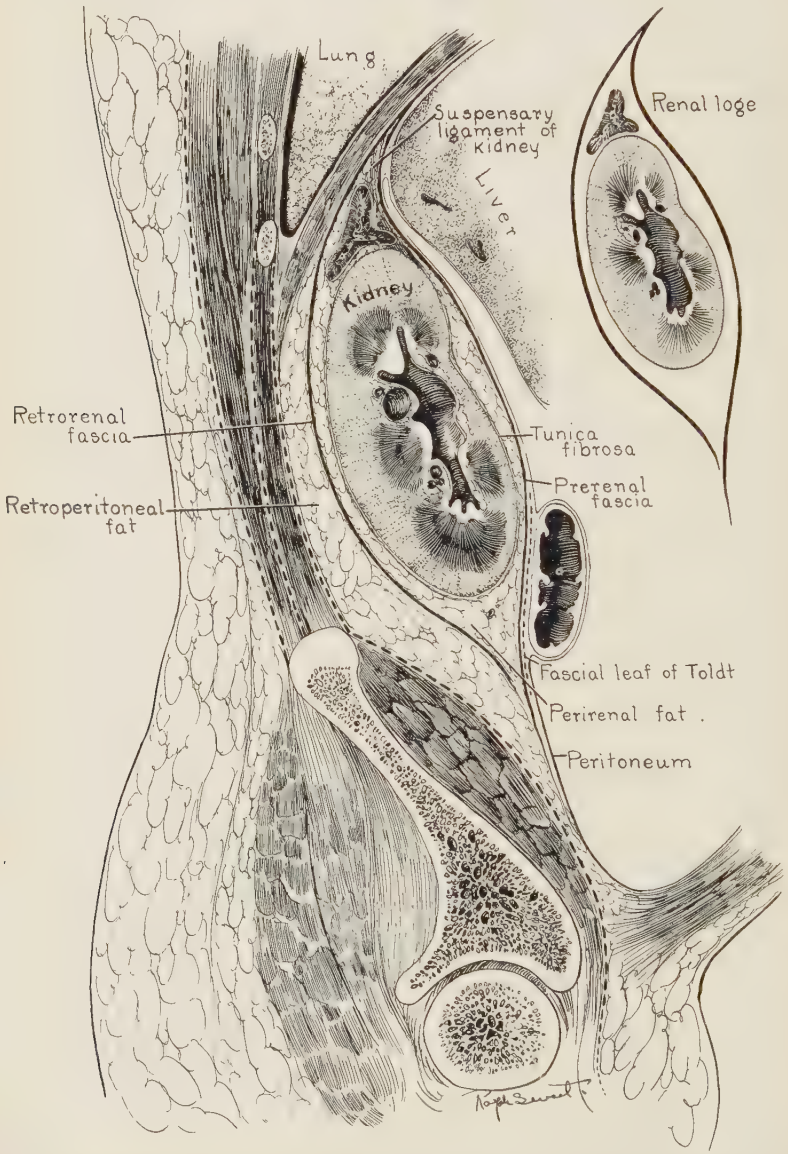


FIG. 185.—Longitudinal section through the kidney region, showing in a particularly graphic manner the arrangement of the structures surrounding the kidney. (Mathé.)

with the subperitoneal tissues. A knowledge of the arrangement of this fascial envelope is of especial interest to the surgeon, as it makes it possible to pass from one kidney to the other without going outside the fascia at all.

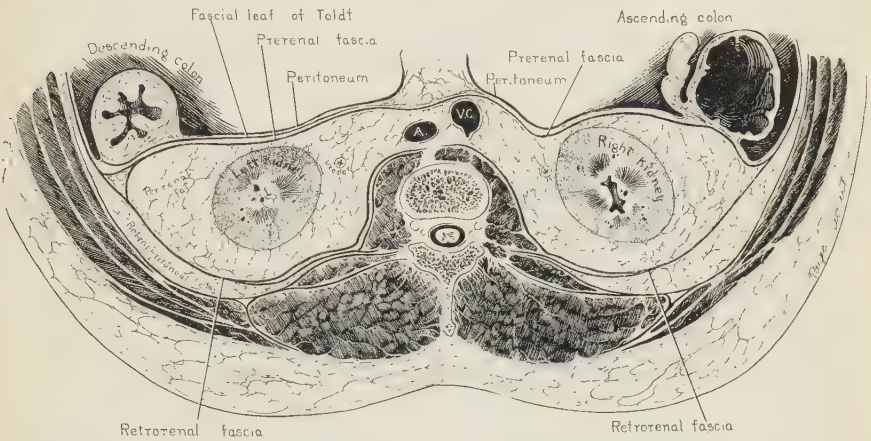


FIG. 186.—Cross-section through the entire back, at the level of lower poles of both kidneys, showing the relations of the tissues in that region. (Mathé.)

Hilum and Pelvis.—The upper pole of the "bean" is wider and thinner than the lower one, and the convexity of the outer border is very marked, although the medial border, on the contrary, is concave. At the center of this medial border we find the hilum renalis, which is a deep sulcus forming the point of entry for the renal artery, as well as the place whence the ureter and the renal vein make their exit. The continuation of the hilum is known as the *sinus renalis* which penetrates the kidney in a longitudinal direction and forms the *renal pelvis*. The pelvis, in turn, is subdivided into three or more terminal chambers called *calyces*.

Divisions of the Pelvis.—In the human kidney there are three divisions, the *pelvis*, the *medulla* and the *cortex*. The pelvis is the hollow cavity communicating below and within with the ureter, and from without receiving the openings of the main ducts of the medulla and cortex which are composed of a mass of tubules. These tubules are of two types, *secreting* of which the renal cortex is composed, and *collecting* or *conducting* tubules, which make up the major portion of the medullary part of the kidney.

Renal Circulation.—At the hilum the *renal artery* enters the kidney, there dividing into branches which pass onward toward the cortex, thence turning over and forming incomplete arches in the area intervening between medulla and cortex. The *interlobular arteries* pass from these arches to the surface, giving off at right angles vessels which are subdivided again and again until they are reduced to minute

capillaries which ramify between the convoluted tubules, later uniting to form the interlobular veins which accompany the interlobular arteries, and eventually combining into the *renal vein*, which returns the blood through the hilum into the general circulation.

Lymph Vessels.—The renal lymph vessels are very numerous, and ramifications of the lymphatic system are extensively distributed throughout the kidney. Most of these lymphatic chains unite and pass from the kidney through Bertini's columns, several good-sized lymphatic trunks being found at the hilum where they communicate with the adjacent lymph glands. Some lymphatics may also be found passing through the fibrous kidney capsule itself.

Nerve Supply.—The renal plexus which lies at either side, consists of both medullated and non-medullated nerve-fibers, with collections of ganglion cells. Large nerve trunks enter the hilum along with the bloodvessels, being then broken up into finer filaments which find their terminations in the walls of the vessels and also in the walls of the epithelial tubules. The nerve cells on the course of the constrictor fibers are situated in the cœliac, mesenteric and renal ganglia; the nerve cells on the course of the dilator fibers are placed in the cœliac plexus and renal ganglia.[41] The vagus also sends branches to the renal ganglia.

Function of the Kidney.—The function of the kidney is to secrete urine, and to keep the blood of a constant and uniform composition by separating the urinary constituents from it. So nicely adjusted to this function are the kidneys that changes in the composition of the blood, far too minute to be detected by chemical analysis, can yet be perceived by these organs, as their response by increased secretion or *diuresis*, will indicate. Some of these constituents of urine, urea being perhaps the most notable example, are eliminated practically entirely by the kidney; again, only the excess above a certain quantity, as is the case with sodium chloride, will be subject to the kidneys' selective action. The exact process by which the kidney function is discharged is by no means established and has been, as indeed, it still is, the subject of much dispute among physiologists. This is discussed more at length in connection with the performance of tests for the determination of renal function.

Histology.—We have seen that the renal cortex is composed of secreting tubules and the medullary portion of collecting tubules. The striated appearance of the normal medulla is due to the fact that the conducting tubules run parallel to one another as well as in a generally radial direction. These tubules do not empty directly into the pelvis but are tributaries to main ducts, a number of which, normally from ten to fifteen, open at the summit of a little papilla into the pelvis. The so-called *medullary rays* consist of these receiving ducts with their tributary system of smaller tubules, which form visible subdivisions of the medulla.

Bowman's Capsule.—At the upper end of each tributary tubule is a small sac or blind dilatation which serves to drain this higher portion.

This sac is lined with epithelial cells slightly flattened, the lining being folded back over the convoluted bundle of capillaries with which the sac is filled. This sac with its contained capillaries, sometimes called the *Malpighian corpuscle*, has heretofore been designated by its more common name of *Bowman's capsule*, the bundle of capillaries being its *glomerulus*. In the adult this glomerulus varies in diameter from 0.1 mm. to 0.15 mm. The artery leading into the glomerulus which is called the *vas afferens*, is larger than that which conveys the blood away from it, which bears the name of *vas efferens*. Both of these arteries however, enter and leave at the same point, the hilum of the

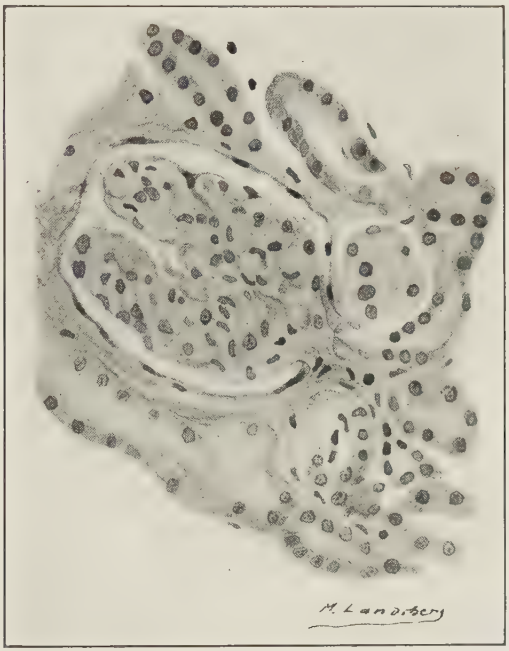


FIG. 187.—Microscopic section showing a glomerulus, with cross-sections of some of the tubules in its vicinity.

glomerulus, which is ordinarily located upon the surface nearest the renal capsule. The glomerulus, which has been referred to as a tuft of bloodvessels, is really a small labyrinth of arteries of pre-capillary size. These are held together by connective tissue, and the epithelial lining, as has already been mentioned, dips down into the clefts between the vascular loops.[50]

Tubulus Contortus.—Bowman's capsule opens into the upper portion of its tubule by way of a short neck. The first portion of the tubule which follows the neck proper is known as the tubulus contortus and proximal convoluted tubule. Its highly irregular course is lined by tall columnar epithelial cells, which upon careful scrutiny will show

rows of radially disposed granules, the inner margins of the cells being equipped with fine hairs springing from the periphery. The tubulus contortus opens upon the upper end of a U-shaped loop which dips down into the medulla, and is known as the *loop of Henle*. The cells lining the descending limb of this loop are flattened and cuboidal, but those of the ascending limb are very like the cells which make up the convoluted tubules. The ascending limb of Henle's loop passes by a transitional tubule lined with cuboidal cells, into a distal convoluted tubule precisely like the tubulus contortus, which in turn opens into a collecting tubule, which shows once again a lining of flattened cuboidal cells, the protoplasm being clear. Communication with the renal pelvis is established through a duct which opens at one of the papillæ of the pelvis, permitting the passage of the collecting tubule. The course of this structure is fairly straight, extending from the periphery of the medullary ray to the point of the papilla. In the boundary zone it unites with similar collecting tubules, and by a continuous series of such unions becomes steadily greater in size, until it at last emerges as a papillary duct.

Number of Tubules.—It has been estimated that there are about 40,000 collecting tubules of an average length of 2 cm. in one human kidney. The bulk of the cortex measures about 120 cc., while that of the medulla measures approximately 30 cc. There are some 20,000 lobules or units in a kidney, four-fifths of which reach the surface, the rest being in cortical columns. The number of glomeruli in one kidney is perhaps 2,000,000, with an equal number of uriniferous tubules of an average length of 3 cm. each, making the combined length of the uriniferous tubules of a single kidney 60 kilometers, or 37 miles.[30]

Macroscopical Appearance.—The disposition of this vast number of tubes while actually highly intricate, is yet so regulated as to produce a macroscopical appearance which is practically identical in the different parts of the entire organ. Each lobe of the kidney may be likened to a cone, the apex of which has been cut off and its place supplied by the apex of a smaller cone. A vertical section cut through this cone will show clearly the triangular portion in the center which has already been mentioned as the *medullary pyramid*, outside of which can be seen the *cortical portion*: the medulla representing the pith and the cortex the bark, as their names indicate. The capsule which covers the lobe is of condensed areolar tissue, which is only a continuation of that which envelops the calyx; and lying immediately beneath it will be found a layer of fine unstriped muscle tissue. The tubules and blood-vessels are supported by interstitial connective tissue which is very scanty except above the Bowman's capsules and in the papillary region, where it is fairly abundant. At the surface where it comes into intimate connection with the true capsule, it is much condensed.

The usual number of lobes in a single kidney is from eight to twenty. Though we have seen that they are separate initially, their adjacent surfaces later coalesce, the apices converging and the papillæ projecting

in such a way as to form the central cavity known as the *renal sinus*. If the kidney is sectioned in that part where fusion is complete, it will be evident that the pyramids are separated by masses of cortical substance, which are identified as the *columna renalis*, or Bertini's columns, as they were described in considering the embryology of the kidney. Here the cortex will have the appearance of curving across the base of each pyramid from one column to another, whence comes the name of *cortical arches*.[45]

ANOMALIES OF THE KIDNEY.

Anomalous Renal Bloodvessels.—Before discussing the renal anomalies which are ordinarily set forth in text-books, and which, though actually rare, have been so much written up as to be comparatively familiar even to those who have never encountered them in actual practice, it is our intention to give particular attention to a subject of vital importance to every surgeon operating upon the kidney, and to which comparatively little attention is given by those writers who have heretofore produced literature relating to kidney surgery. This is the occurrence of anomalous accessory vessels to the upper and lower poles of the kidney. Practically no observations on this subject were published until the Anatomical Societies of Great Britain and Ireland reported the result of their investigations in 1891. Eighteen years later, Seldowitsch, a German observer examined 300 kidneys which he had dissected with a view to obtaining data relating to accessory vessels, and in this country a systematic research upon the subject was undertaken by D. N. Eisendrath.[26] It is to the thorough and exhaustive researches and the unflagging zeal of this investigator that American surgeons owe the precise information concerning accessory renal vessels which is now at their disposal.

A *superior polar artery arising from the main renal artery* is as a rule very short, taking its rise from the main renal artery at a point just before that at which the main renal artery enters the hilus. It may, however, have its origin further back, nearer to the aorta, so close in fact, that for all surgical purposes it will have the same significance as one arising directly from the aorta. By careful consideration it can be easily seen how a long superior polar accessory to the main renal might be torn by the surgeon quite as readily as an artery derived directly from the aorta, and also how, in those cases where such an accessory vessel is short, it can escape being included in the ligation or clamping of the renal pedicle.

Superior polar arteries from the aorta usually enter the mesial border of the kidney, rarely upon the anterior or posterior surfaces. In the majority of cases there is but one such artery which may be found upon either side, but in a fair percentage of subjects, 2.5 and 5.9 per cent in Eisendrath's two series of investigations, a superior polar

artery did arise from the aorta. In some subjects there is a superior polar artery to each kidney.

An *inferior polar from the main renal artery* was found once in Eisendrath's 109 subjects. This could easily have been overlooked while freeing the lower pole of the kidney during operation.

Inferior polar arteries from the aorta are of great importance from the stand-point of their relation to ureteral compression with resultant obstruction. There is also great likelihood of their being torn during nephrectomy, such an accident being almost certain to be followed by retraction of the bleeding stump toward the accessory vessel's point of origin in the aorta. In some subjects such an accessory vessel will originate quite close to the iliacs. Such inferior polars not infrequently occur on both sides, and two inferior polar arteries may be present anomalously in the same way. Either of these pairs of accessory vessels may be accompanied by a corresponding inferior polar vein. When two main renal arteries are present they may be so far apart that one of them may be mistaken for an accessory artery to the lower pole.

An *inferior polar artery arising from the iliacs* is occasionally encountered, and it is well known that lower pole renal vessels may take their origin not only from the common and internal iliacs, but also from the middle, sacral or even the inferior mesenteric arteries.

A *summary of the findings of various special investigators* reveals the following facts: (1) Upper polar arteries arising from main renals occur in about 1 out of 200 kidneys; (2) upper polars arising from the aorta in about 1 out of 190 kidneys; (3) lower polars from the main renal, the aorta, or common iliacs in 1 out of about 185 kidneys.

Retropelvic Vessels.—The commonly accepted arch-like distribution of the retropelvic artery is frequently subject to variations, and it is quite possible that the surgeon who undertakes a pyelotomy may find the field of operation crossed by one or more anomalous veins of large size, or even by the main renal. The generally accepted course of the main retropelvic artery is called by Eisendrath the *high type*, to distinguish it from extra vessels which may give rise to troublesome bleeding during pyelotomy, such as: (*a*) A high middle and low or fan-like distribution; (*b*) a high and middle type of branching; (*c*) a high and low type; (*d*) a single artery crossing the middle of the pelvis; and finally (*e*) a middle and low type; all of which occurred two or more times in 124 kidney dissections. Division of the single main renal artery into equal-sized branches was a common finding, and where there were two main renal arteries, one of these frequently became the retropelvic, taking its rise directly from the aorta instead of from the main renal artery.

Anomalies of the Retropelvic Veins.—A large vein may arise from the vena cava and pass directly back of the renal pelvis. Again, the main renal vein may divide into branches of equal size which pass before and behind the pelvis, the retropelvic branch going directly across

where it could be easily injured during a pyelotomy. Most important of all, the main renal vein, instead of being prepelvic, may be retropelvic, this anomaly being found in 9 out of 218 kidneys, a trifle more than 4 per cent.

Anomalies of both retropelvic vein and artery are not uncommon. A large vein directly from the vena cava and an artery directly from the aorta have been found crossing the back of the pelvis, and in 1 instance there were two veins which crossed an artery derived from the aorta back of the pelvis.

Operative Precautions in Regard to Anomalous Renal Vessels have been suggested by Eisendrath as follows:

1. During nephrectomy or even nephrotomy, the poles of the kidney should be most carefully exposed. The mobilization of the kidney should be gradual, care being taken both at the lower and upper poles never to tear or divide adhesions or strands of fibrous tissue before they have been inspected and also palpated (for a possible pulsation) to exclude the presence of a supernumerary vessel. Kolisher's suggestion that in nephrectomy the ureter should be divided before attempting to mobilize the kidney, is excellent.

2. In pyelotomy careful exposure of the pelvis before the incision for the delivery of a calculus is made, will greatly lessen the chances of encountering an anomalous vein or artery.

Anomalies in Number, Position, or Form of the Kidney.—*Extra kidneys* are very rare indeed, and in the few cases in which they have been encountered they were found lying at some point in the course of the ureters, or lying between the ureters in front of the spinal column.

Double renal pelvis is a fairly frequent anomaly. This condition may vary from the mere separation of two portions of the pelvis shown in Fig. 188 to complete separation of pelvis and ureter, as seen in Fig. 189. *Absence* of one kidney is a much more common and an infinitely more important condition. The lack of one renal organ may be due to a congenital abnormality, or may be the result of disease. In either case, the knowledge of this absence is very essential to any physician or surgeon under whose care a patient with this faulty urinary equipment may come. Absence of one kidney has been reckoned as occurring once in about 2500 cases;[41] the left kidney is the one more often missing, and the anomaly is twice as frequent in males as in females.

Unilateral Hypertrophy.—Whether the kidney be congenitally absent, or has ceased to function because of injury or disease, the effect upon its fellow will be the same. As the surviving organ must now carry all the burden of urinary secreton, it will gradually become larger in order to meet the increased demands made upon it, and this compensatory hypertrophy will in most instances, be evident upon examination. Therefore, whenever such examination reveals one kidney of unusual size, the urologist should at once be on his guard, and any intervention upon such an organ should be undertaken only after thorough explora-

tion of the entire urinary apparatus. More than once, in the days when so many diagnostic resources were not available, a single kidney, or the only functionating one, has been cripppled, or even entirely excised, with inevitably fatal results. Even today, such an accident occasionally occurs.

Congenital Single Kidney.– In 1910 Anders[2] collected 61 cases of undoubted congenital single kidney, and by reviewing statistics compiled at various times found that from a grand total of 92,690

FIG. 188.—Incomplete unilateral duplication of the renal pelvis. This slight defect is very prevalent and has no particular significance.

autopsies, the condition had been observed at a ratio of 1 to every 1817 postmortem examinations. The results of such a review emphasize very strongly the fact that the possessors of but a single kidney are far more prone to die of renal complaints than those who are normally equipped in this respect. When a stone occludes the ureter of a solitary kidney, the danger to life is infinitely greater than under ordinary conditions, so if there is the slightest reason to suppose that an anomaly exists, relief should be afforded as promptly as possible, although any surgical intervention must be thoroughly considered and

conservative. The prognosis given for any renal disturbance in a patient with but one kidney should always be a guarded one.

Abnormal Location of One or Both Kidneys.—It sometimes happens that one or both kidneys may occupy an abnormal position, the organs being found somewhere between their proper location and the base of the bladder, as was mentioned in the case of supernumerary kidneys. There may be a single kidney situated somewhere near the middle line, but it is more likely that one or both organs may be discovered far down in the pelvis, lying in the normal course of the ureters.

FIG. 189.—Complete unilateral duplication. Both ureters extend independently to the bladder. As a rule the ureter from the upper pelvis crosses the other and its orifice is nearest the vesical neck.

Anomalous Form.—If the position of a kidney is abnormal, it will follow almost inevitably that its form will be abnormal also. The most common deformity is that which is known as "horse-shoe kidney." This term is usually extended to include almost any description of fused kidney, as for example, the "dumb-bell kidney" reported from the laboratory of the University of Pennsylvania about eight years ago.[42]

Horseshoe Kidney. - Horseshoe kidney is usually found in the median abdominal line about the level of the umbilicus, but not infrequently, it will be discovered lying diagonally with one pole extending down into the bony pelvis. The patient's attention will be directed to such a kidney only when it becomes the seat of a pathological process giving rise to a visible tumor mass, or gives pain in the

FIG. 190.—Crossed pelvic dystopia of kidney. The kidney, which is normally in the left loin, has descended into the right pelvis, and rotated in such a manner that the renal pelvis points upward and to the left.

median area of the abdomen. If complications involve one-half of a symmetrically lying horseshoe kidney, the pain may be more lateral than median,[11] but if the kidney be asymmetrically placed, the median lying pole, which is usually the lower, is generally the one involved, with consequent distinctly median pain and tumor. While palpation might determine a mass lying across the median abdomen,

so that the examiner's suspicions of the possibility of horseshoe kidney would be aroused, it could not be positively identified as such. A rectro-peritoneal mass felt through the rectum may offer corroborative data, particularly if the position of the adjacent large bloodvessels can be determined.

FIG. 191.—Unilateral double kidney on the right side. The ureter which has its orifice on the left side crosses over to the lower pelvis. Both renal pelves point toward the left side. The upper one is normal, the lower one is infected. Occupying a position under McBurney's point explains the diagnosis of appendicitis which was once made on this patient.

Roentgenography is not often of much assistance in making a diagnosis of fused kidney, as the shadow is usually too indefinite to permit accurate interpretation[47] except in very thin patients, with whom the outline may be sufficiently clear to be suggestive. At the Mayo Clinic it was found that a stone in the fused renal pelvis often casts a shadow

approximately in the normal position, but if the shadow of the stone lies at an oblique angle and extends toward the median line it should be regarded as suggestive of fusion.

Inasmuch as fused kidneys seem more liable to disease than do normal ones, the condition comes under observation with comparative frequency, and the diagnosis is of the greatest surgical interest and importance. While operation upon such a kidney presents more difficulty than is usually encountered in renal surgery, the results, other factors being the same, seem to be quite as satisfactory as those obtained upon organs which are normal in shape and position. Operation for the separation of the fused organs has occasionally been undertaken, but the outcome has not justified such measures except in an extreme emergency.[53]

Unilateral fused kidney should be differentiated both from solitary kidney and from the "horseshoe" anomaly, as in this type of malformation the ureters invariably open into the bladder in the normal way, so that even careful cystoscopy may not give the slightest hint of the actual state of affairs. In the great majority of unilateral fused kidneys the displaced organ lies below the normally situated one, its upper pole fused with the lower pole of the latter. The ureters always arise from separate and clearly-defined pelves lying one above the other. The ureter from the upper pelvis passes down to enter the same side of the bladder; that from the lower section crosses the median line and enters the bladder from the opposite side.

Atrophy of the Kidney.—Atrophy of the kidney may be either congenital or acquired, and its recognition is often attended with great difficulty. If the atrophy is marked however, there is likely to be so great a degree of compensatory hypertrophy in the opposite organ that its unusual size will suggest the condition existing in its fellow. The cystoscope may be of great aid in diagnosis; examination of the ureteral orifice will show atrophy of the circular muscle usually seen about it when normal; contraction will be slight and the secretion scanty and appearing at irregular intervals; while the opposite orifice will give evidence of increased power, enabling it to do the work of both sides. Atrophy of the ureter is the usual accompaniment of an atrophic kidney, and the size of the lumen will be so reduced that even a very small catheter cannot be passed without difficulty. When this is evident upon attempted examination, atrophy of the kidney may at once be suspected.

TRAUMATIC INJURIES TO THE KIDNEY.

Traumatic injuries to the kidney are usually divided as follows:[59]

1. Those due to *direct trauma*; kicks, blows, falls upon hard surfaces or objects such as stones, timbers, etc.; crushing between two surfaces, as being caught between two moving vehicles, wheels and so forth;

or trauma from any cause where force is brought to bear directly over the renal area.

2. Those due to *indirect trauma*, violent horseback riding, falls upon the feet, etc.

3. Those due to *muscular action*, sudden movements, as those made dodging blows, reaching to catch something, springing suddenly backward, or heavy lifting.

Gunshot wounds and stab wounds would, of course, fall under the first classification, but because of certain peculiarities arising from their penetrating character, may more properly be considered separately.

Slight Trauma May Produce Severe Injury.—A perusal of the literature regarding traumatic injuries to the kidney impresses one with the fact that the blow or force which produces them need not necessarily be severe in character. At times the accident has been of so slight a nature that the patient was at first unable to recall it when, after the lapse of considerable time, hematuria or some similar manifestation indicated that renal trauma had taken place. Even when the kidney is badly lacerated, it may be some time before blood will appear in the urine, which is probably because the ureter is occluded by clots. But the passage of such clots causes the same kind of pain as that produced by the evacuation of a calculus, so that when this occurs the patient's complaints will ordinarily assist in establishing the gravity of the injury.[89]

Indications of Kidney Injury.—In general however, considerable force is required to cause serious damage to the kidneys, as anatomically they lie in a well protected position, shielded above by the bony covering of the ribs. Even when the blow has been a severe one, slight hematuria may be the only evidence that any injury has been sustained. If the kidney tissue has actually been lacerated more pronounced symptoms will usually be manifested, depending upon the extent of the damage and the condition of the adjacent structures. Shock is likely to be marked, and the nausea and vomiting which are the customary accompaniment of abdominal injury and internal hemorrhage, will be in evidence. Injury to the kidney following any kind of trauma is likely to vary all the way from tears of the fatty capsule, localized subcapsular hemorrhage, slight contusion or laceration of the parenchyma, or other comparatively trivial lesions, to rupture of the renal pelvis, injuries to the renal bloodvessels, complete rupture, single or multiple, or general pulpefaction, with or without complicating rupture of the peritoneum, or injury to other structures near by.

Indirect trauma may cause injury to the kidneys when there has been an acute flexion of the body with corresponding acute flexion of the kidney on its transverse axis; or, as has happened in cases where the patient has sat down hard, the fall from a height upon the buttocks may injure the kidney by direct impact against the twelfth rib or transverse process of the first lumbar vertebra. Under such cir-

cumstances the diagnosis will be difficult, if not altogether impossible, for frequently there will be no hematuria and palpation will not yield any definite information.

Symptoms.—If the peritoneum be torn following either direct or indirect trauma, especially if there are injuries to the abdominal viscera, muscular rigidity will be more pronounced, and vomiting more likely to occur, than in uncomplicated cases. If there is much loss of blood, even in the early stages the leukocyte count will be high, from 20,000 to 30,000. If a sufficient time has elapsed, infection of the perirenal tissue may produce a temperature ranging from 103° to 105°F. The condition of the patient is usually too grave to permit a cystoscopic examination, but if possible, this should be undertaken, and will always be necessary later on, in order to ascertain the amount of urine coming from the injured side.[79]

Dangers.—In all forms of renal trauma hemorrhage is the most constant and severe symptom. Shock due to sudden loss of blood is usually the cause of death in the immediately fatal cases. The second and more remote danger is that of infection. This is ordinarily in evidence some forty-eight hours after the initial injury, and if the lesion does not reach as far as the tubules and the renal pelvis there is a possibility that infection will not take place, that the blood will be absorbed and the kidney wound heal spontaneously.[46] But usually, after the lapse of forty-eight hours septic changes will occur, and perirenal infection will be manifested by chills and irregular temperature, while the urine will be loaded with pus. The infection may take the form of a walled-off abscess, but it is often a diffuse cellulitis, extending into all the surrounding tissues. Earlier exploration may save some kidneys which if seen long after the accident, can be treated only by nephrectomy; for after infection has set in, it is not possible to pack the rent in the renal tissue, or to clear away the clots, so that the wound can be successfully sutured.

If the surgeon is able to make an inspection before infection begins and finds a viable kidney not too badly torn, it will frequently be possible to make a loose suture and provide free drainage, thus saving the organ practically intact. But in the presence of extensive laceration, especially if the vessels are severely injured, or if the ureter has been torn loose, excision is the only safe procedure.

Rupture of Previously Diseased Kidney.—Not only is rupture more likely to take place in an anomalous kidney than in a normal one, but an organ previously diseased is also more liable to traumatic injury than a sound one; and the outcome, of course, will be greatly influenced by preëxisting pathological conditions. This consideration is of especial importance in industrial surgery, for renal trauma in times of peace is most frequently due to accidents occurring in the pursuit of the patient's regular occupation. The necessity of fixing the liability which has arisen since the enactment of workmen's compensation acts in many states, has rendered it increasingly

important to determine exactly the mechanism by which such accidents as kidney rupture occur, and whether the lesion is wholly due to the trauma sustained, or is influenced by preëxisting conditions.[57]

Problems of Industrial Surgery.—When undoubted injury has been sustained by the kidney it still remains at times a difficult matter to decide whether the urinary symptoms existed before the accident but are now aggravated, or whether a perfectly honest patient may not have first noticed preëxisting symptoms after the accident had called his attention to them. The problem of deciding how great a factor in the present disability the trauma really has been may be a very difficult one in considering individuals with infectious lesions such as a mild chronic pyelitis, when a hematuria is adduced as an evidence of kidney injury. Whether the pyelitis really produced the hematuria, or possibly whether the pyelitis might not have been induced by the trauma, or at least greatly increased by it, must be carefully investigated by the physician who is called upon to give an opinion regarding causation.

Interpretation of Roentgenograms.—Another difficulty likely to be encountered by the industrial urologist is the question of liability based on the wrong interpretation of roentgenograms. For example, when the victim of an accident has been examined radiographically shadows may appear in the plate which are interpreted as stones, and the attending physician will tell his patient that, as the result of the trauma, he has developed renal calculus. Of course, if the shadows are of extra-renal origin this fact can be easily demonstrated by the methods discussed in the chapter on Radiographic Diagnosis, so the examiner should not fail to make use of all these aids before coming to a decision.

Gunshot Wounds of the Kidney.—During and since the World War the subject of gunshot and other projectile wounds has received a wide amount of attention. It would seem that since the return of peace injuries of this nature have been more frequently seen in civil practice than was the case previous to 1914, and wounds in the renal area have formed a fair proportion of those reported.

War injuries may be classified as shell wounds, bullet wounds (including shrapnel), stab wounds and ruptures. Shell wounds, which are usually large and destructive, and almost invariably are associated with graver visceral injuries, usually require primary nephrectomy. Bullet wounds, if they involve the hilum, usually sever the vessels of the pedicle, so that they likewise call for nephrectomy. If the wound is parenchymal, the bullet merely traversing the kidney, excision of the tract and packing may be all the treatment required; but if the kidney is ruptured by the passage of the bullet, excision will be the only safe course for the surgeon to pursue. Stab wounds, which are rare, are characterized by severe primary hemorrhage. Subcutaneous rupture of the kidney is identical with that condition as encountered in civil practice.[86]

Primary gunshot wounds of the kidney are relatively rare; as a rule other abdominal viscera will be injured, especially the stomach, duodenum and colon. Frequently the peritoneum is involved, though this is by no means always the case. Whether or not the injury is fatal depends largely on the point at which the missile penetrates; if the point of entry is near the periphery of the organ, the prognosis is favorable; if the pelvis is involved, the situation is more serious, for then there will be extravasation of urine into the surrounding tissues, and there is likelihood of some of the larger vessels being involved in the injury, which will produce severe hemorrhage. When the peritoneum also is injured, the extravasated urine will in all probability, set up a generalized peritonitis, and even if the peritoneum has managed to escape unscathed, a subphrenic abscess may result from the escape of urine.

If the wound is caused by a revolver bullet of high velocity and small caliber, the destruction of renal tissue will not be so great as with some other form of missile, and the prognosis will be correspondingly better. The angle at which the bullet strikes must also be considered; if the impact is nearly at right angles, the laceration may be trifling, but when it arrives at an acute angle its course is likely to encounter larger vessels, so that the resulting injury is inevitably much greater.[25]

It was noted by British medical officers[33] that though intraperitoneal hemorrhage, in direct contrast to the kidney trauma encountered in civil practice, was a frequent finding, the shock as a rule, was not great, and this was regarded as peculiar when one remembers the effect produced by the kidney blow in boxing. The treatment was usually packing, suture, or nothing, the amount of hemorrhage being the guide in each case individually. It is believed that many of these war patients might have recovered without any surgical intervention, but this had to be undertaken in order to exclude other abdominal injury. Hemorrhage from wounded kidneys is very liable to restart with alarming rapidity directly the clots are disturbed. Most of the deaths which occurred when the kidney alone was wounded were due to shock and hemorrhage. Of those who survived to reach the base hospital, secondary hemorrhage and sepsis played the chief role in the ultimately fatal results.

Cystoscopy was resorted to in a number of cases[34] in order to determine the effect of the wound on the function of the injured kidney; to gain information as to the presence and condition of the kidney of the opposite side; to learn whether the injury was confined to one kidney only, and if so, which; and to ascertain by means of pyelography the position of the retained missile relative to the kidney or ureter. Other means of diagnosis were resorted to in cases where a missile had apparently come in contact with the kidney, but as the condition did not warrant operation, the exact diagnosis was impossible. Diminished specific gravity on the affected side indicated a disturbance in function, the kidney probably being unable to separate the

solid constituents of the urine from the blood in normal quantity. In other instances disturbance of function was indicated by some alteration of the permeability of the kidney to dyes, such as indigo-carmine. Exaggeration, diminution or irregularity of elimination indicate pathological renal permeability. When the wound had been sustained some time before, cystoscopy was useful in detecting abnormal constituents in the urine such as blood, pus, albumin and microörganisms, which had their origin on the affected side. If the patient was septic however, albumin might be found on both sides, and a few blood cells be present as the result of even the most careful catheterization. A preëxisting cystitis may introduce a few pus cells into the catheter during its passage through the bladder, and microörganisms may get in even when the cystoscopy is most painstakingly carried out. Yet with all these drawbacks, comparison of the two sides proved of much value in renal war surgery.

Roentgenographic examination was also of service in locating retained foreign bodies in the renal area, which enabled the surgeons to form an idea of the course taken by the missile and to estimate what other structures had been injured by its passage. The shadowgraph catheter was also employed by passing it into the kidney pelvis and making use of stereoscopic radiography when the missile was thought to be lodged in the vicinity of the kidney or ureter.

Gunshot Injuries in Civil Practice.—The gunshot injuries of civil practice do not present many problems not found in those encountered in war time, and as a rule are easier to handle because they are not so often associated with serious sounds of other viscera. On the other hand, they do not uniformly occur in young and previously healthy subjects as do the wounds of military practice, so that preëxisting complications must often be taken into consideration. Conservative treatment is more often possible because of the better conditions with which the patient can be surrounded, yet postwar advice from German surgeons[76] urges the exposure of the injured viscus for thorough examination, which should be done through a lumbar incision, as the transperitoneal route does not insure the recognition of certain types of renal injury and, especially if other organs, the liver for example, have been lacerated—even very serious damage to the kidney may be altogether overlooked.

Bullet wounds in civil practice, being commonly inflicted at short range, are far less liable to produce extensive lacerations, though they are none the less fatal in their effects. If the general condition is good, however, many surgeons delay intervention or avoid it altogether, but although the outcome of some of their cases may be satisfactory, in general, the policy of watchful waiting is not to be recommended. If the course pursued by the bullet indicates that abdominal perforation has taken place, exploratory laparotomy should be undertaken to determine the exact nature and extent of the injury, subject of course to the patient's general condition, and the degree of shock

which has been sustained. When the chest as well as the abdomen has been perforated and there is evidence of grave thoracic trauma manifested by dyspnœa, rapid pulse or marked signs of hemo- or pneumothorax, these conditions should first receive proper attention, the chest being opened to repair the lungs and control hemorrhage. For such cases transthoracic laparotomy is recommended." The thoracic approach offers especial advantages for proper exploration of the chest, and likewise permits access to the intra-abdominal organs, especially those just beneath the diaphragm.

Choice of Operative Procedure.—When it is definitely established that the course of the bullet is through the abdomen and kidney, there will always be some doubt as to whether it is best to open the abdomen first, or to commence by a lumbar incision for exposure of the kidney. The existence of severe hemorrhage, if one can be certain that it has its origin in the kidney, should be an indication for beginning in the renal area, for there is likelihood that perforation of the intestine has occurred as the missile passed through the abdomen, and any chance of infection being conveyed into the retroperitoneal space may be avoided by attending to the kidney before doing a laparotomy. Speaking generally, if in doubt, first expose the kidney, using a lumbar rather than a transperitoneal incision.

The best handling of gunshot wounds of the kidney, whether in military or civil practice, has been excellently summed up in the *Manual* prepared for the Division of Urology, Medical Corps of the American Expeditionary Forces.

"In general, all patients with abdominal injuries should be catheterized unless they can urinate freely, and the urine should be examined for blood. If shock is present, it should be treated in the usual manner, by warmth and transfusion. If in doubt when to operate, the most prudent decision is usually the wisest. If there is a wound of the loin and hematuria, or if the wound plainly leads to the kidney, enlarge it transversely, deliver the kidney and examine the hilum for lesions of the renal vessels: if the main artery or vein, or the upper main branch of the artery is wounded, perform nephrectomy. If more than one-third of the kidney is contused, perform nephrectomy; if less, resection may be considered. If smaller arteries or the lower branch of the renal artery are wounded, excise a cone-shaped portion of the kidney corresponding to the area supplied by this vessel, excise contused parenchyma in the neighborhood of the wound and explore the renal pelvis with the finger or probe to detect the presence of any foreign body.

"If hematuria suggests a renal injury but the wound is remote from the loin, the decision in favor of, or against, immediate operation should be based on the following data:

"(*a*) If the patient is going to die of primary renal hemorrhage he is likely to do so before reaching the dressing station.

"(*b*) While exploration of renal wounds usually starts a fresh hemor-

rhage from the parenchyma, it will also disclose the fact that primary bleeding has already stopped.

"(*c*) Therefore, unless an external wound leads directly to the kidney region, the presence of hematuria, or of retroperitoneal hematoma, is no indication for immediate operation.

"A *retroperitoneal hemorrhage* discovered in the course of a laparotomy may be disregarded, it often does not arise from the renal vessels at all, unless it is of enormous size, in which event it should be evacuated extraperitoneally *before* the intestines are much handled, as it has been found that immediate grave shock results from turning the patient over and operating on his loin after a laparotomy has first been done. Transperitoneal nephrectomy is generally condemned.

"*Instructions in general surgical technic* are: Suture a torn pelvis with interrupted plain catgut; use no silk nor other permanent sutures for fear of secondary sinus formation or persistent fistula. There is no need to suture the pelvis with great nicety, the wound will heal if the ureter drains properly. In order to insure ureteral drainage and to prevent blood clots from occluding the orifice, lead a split tube or a few strands of silkworm gut, into the upper end of the ureter; these must be removed in forty-eight hours. Suture parenchyma with heavy plain catgut, deep sutures about 2 cm. apart, and if necessary, interpose more superficial sutures to stop bleeding. All deep sutures should be placed at right angles to the long axis of the kidney, in order not to obstruct the arteries. A small tube should be left in the pelvis of the kidney, in case it has been opened, for two days, in order to evacuate blood clots and to hasten the return of kidney function by removing intrapelvic pressure."

RENAL DISEASES.

Infections of the Kidney.—Infection may reach the kidney in either of two ways; one by way of the blood stream, commonly termed *descending infection;* the other by the ascent of microörganisms upward through the urinary passages, known as *ascending infection.*

Ascending Infection.—Ascending infection is certainly uncommon, and by many clinicians is regarded as so nearly impossible, as to be altogether negligible in weighing diagnostic possibilities. Though years ago considered as the probable route of infection, increase in our knowledge of blood-borne infections generally, has quite reversed the attitude of the renal surgeon in this particular regard. Within the last few years however, investigators have labored to show that ascending infection is perfectly possible, and should never be omitted from consideration.

If microörganisms do reach the kidney from below, they must of necessity pass upward from the bladder, therefore, the acknowledgement of ascending infection presupposes the existence of cystitis.[72] It is certainly possible for bacteria to pass from the bladder to the

kidney, either through the lymphatics, or directly through the ureter. No satisfactory proof of the lymphatic route has ever been brought forward, although considerable experimentation, some of it highly suggestive, has from time to time been carried on. In regard to the second path, if the uretero-vesical sphincter is perfectly competent and the ureter itself normally resistant, it seems highly improbable that it would permit the upward passage of infecting microörganisms. There has, however, been observed the so-called *ureteral reflux*, studied by Penfield[70] and O'Conor and Wislocki[93] several years ago in laboratory animals, and more recently in human beings by Quinby, Graves and others. All these observations point strongly to a reflux action which, under certain conditions is able to overcome the normal downward peristaltic action of the ureter, and permit the ascent of vesical content.

Hematogenic Infection.—No matter what may have caused the entrance of infective bacteria into the blood, it is well understood that they must pass out through the kidneys. When those excretory organs are sound and the invading bacteria are not especially numerous or virulent, they will probably be eliminated without producing any effect upon the urinary apparatus. But if the kidney has suffered any lowering of resistance, or has been traumatized, as by the presence of a calculus, or there is any impairment of the circulation, such as takes place in stricture of the ureter, displacement, hydronephrosis, or any form of obstruction to the normal outflow of urine, then we have conditions favorable to the retention and propagation of infective organisms. The microörganisms circulating in the blood supply the agent, the stasis of the urinary stream furnishes the opportunity, and the alterations of the kidney structure caused by disease or by trauma open the door for the entrance of the infection.

Pus in the urine is an invariable accompaniment of all hematogenic renal infections. As the infective agents usually lodge in the glomeruli, it is common in this form of kidney infection to find abscess near the surface. These are usually small and multiple at first, later coalescing into a single large collection of pus, which may rupture directly into the renal pelvis, or reach the pelvis indirectly by gradually percolating through the renal tubules. *Pyelitis* means that abscess formation is confined to the kidney pelvis; *pyonephrosis*, that multiple abscesses are disseminated through the cortex of the medullary portion of the kidney. The second of these conditions is much the more serious, as it frequently accompanies or is the product of a pyemia, the renal condition then becoming but a single phase of the general systemic state.

Frequency of Kidney Infections.—The organisms which most frequently cause renal infection are, in the order of their occurrence: Colon bacillus, tuberculosis, infections with staphylococci and streptococci, and less frequently, proteus, typhoid bacillus and pneumococcus; rarely the gonococcus has been proved to be the offending organism.

Infection with Colon Bacilli.—The most common kidney infection is that caused by the colon bacillus. In 85 per cent of a series of kidney infections of all types, this organism was found, 74 per cent being pure infections with this single infective agent.[22] Invasion by the colon bacillus does not lead to abscess formation or destruction of tissue, as is the case with the pyogenic cocci; the result is usually a diffuse inflammation which spreads through the kidney substance, the severity of the process depending upon the number and virulence of the infecting organisms. The kidney will be much enlarged by congestion, and in the early stages will show isolated areas which appear as irregular,

FIG. 192.—Multiple abscesses of the kidney caused by the Staphylococcus aureus. This patient made an uneventful recovery following nephrectomy.

acutely reddened patches with edges streaked downward into the pyramids. As the inflammatory process subsides, these areas lose the acute red color and are replaced by tissue of a paler character. In some instances the whole kidney may present a decidedly reddened surface, owing to the active process involving the whole organ.[24]

Symptoms.—The first symptoms of a colon bacillus infection of the kidney are very likely to be referred to the bladder, but there will invariably be pain and tenderness on palpation over the affected kidney, and the urine will be cloudy, with an acid reaction, this turbidity not clearing up on standing, as the colon bacilli remain in active motion,

instead of sinking to the bottom as is the case with most other bacteria. Under the microscope the pus and organisms will be readily discernible.

Staphylococcus, Streptococcus, Etc. Pyogenic cocci in general are productive of multiple abscess formation in the kidney substance, which frequently reduces the organ to a mere pus-filled shell. The early symptoms of such a suppurative condition are wholly abdominal, and practically identical with those of cholecystitis, appendicitis, hepatic abscess or acute intestinal disturbance. Differential diagnosis is, therefore, very often difficult, and in the early stages frequently impossible. One manifestation which can always be detected is a marked tenderness at the costo-vertebral angle. There will always be

FIG. 193.—Multiple renal abscesses following stone in the ureter. When first seen, five days after the onset of his renal colics, this man had a hemolyzing streptococcus infection of his urine, and blood culture revealed the presence of the same organism in the general circulation. He died seventy-two hours after nephrectomy.

a rise of temperature, although the curve may be extremely irregular, but leukocytosis is not usually high. If the infection is confined to the pelvis there are likely to be chills, and tenderness will be experienced even without pressure in the affected region; if the ureter on the affected side be catheterized the urine thus obtained will yield pus and make it possible to ascertain the nature of the infecting organism by the proper cultural methods.

Casts.—Casts are often found in renal affection of the type just described, but it is a mistake to regard as negative, urine in which no casts are in evidence. As one writer has put it, casts are so intimately connected with the medical diseases of the kidney that many men feel that their absence indicates freedom from any form of renal disease.

Casts, it is true, are not necessarily absent in infections of the kidney, but on account of the large amount of pus often present, they are not often recognized.[18] As the pyogenic cocci generally are possessed of the property of splitting up urea, their presence tends to cause intense irritation to the mucosa lining the secreting portions of the kidney, and as a consequence numerous epithelial cells will always be found in the urinary sediment.

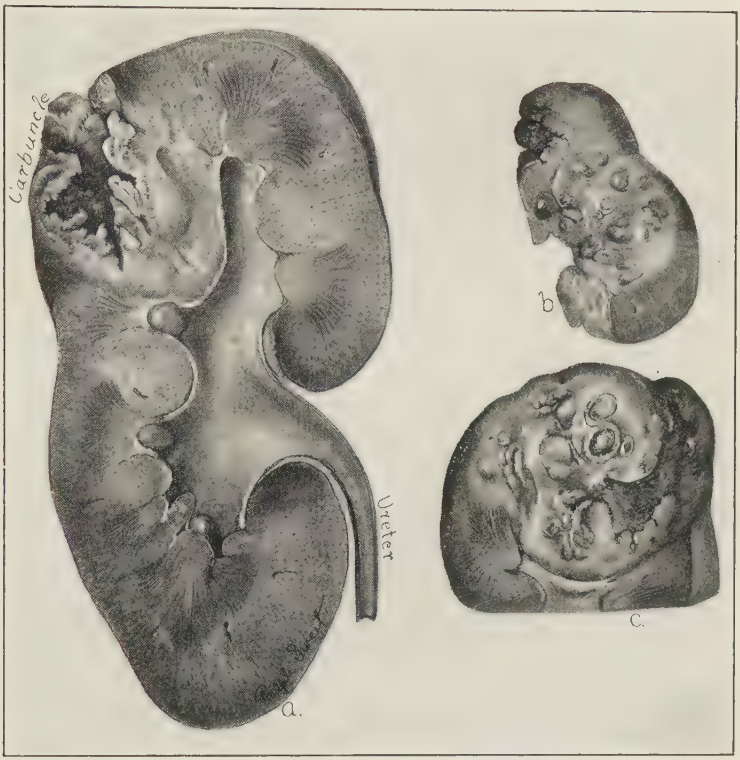


FIG. 194.—*Carbuncle of the kidney.* (Mathé.) The large figure (*a*) shows the carbuncle in the upper pole of the bisected kidney. Insert (*b*) shows its appearance from the outside of the upper pole. Insert (*c*) is direct view of the site of the lesion.

Renal Carbuncle.—Although this is undoubtedly a distinct clinical entity, we have found comparatively few references to it in literature, and there is little doubt that its frequency is greatly underestimated, for the reason that it so often goes unrecognized.

Renal carbuncle is a staphylococcic infection of the kidney, secondary to infection by this organism having its focus in some other part of the body. The etiological relationship is similar to that observed in the production of perinephritic abscess or acute renal sepsis. The infection originates at some point remote from the renal region, the

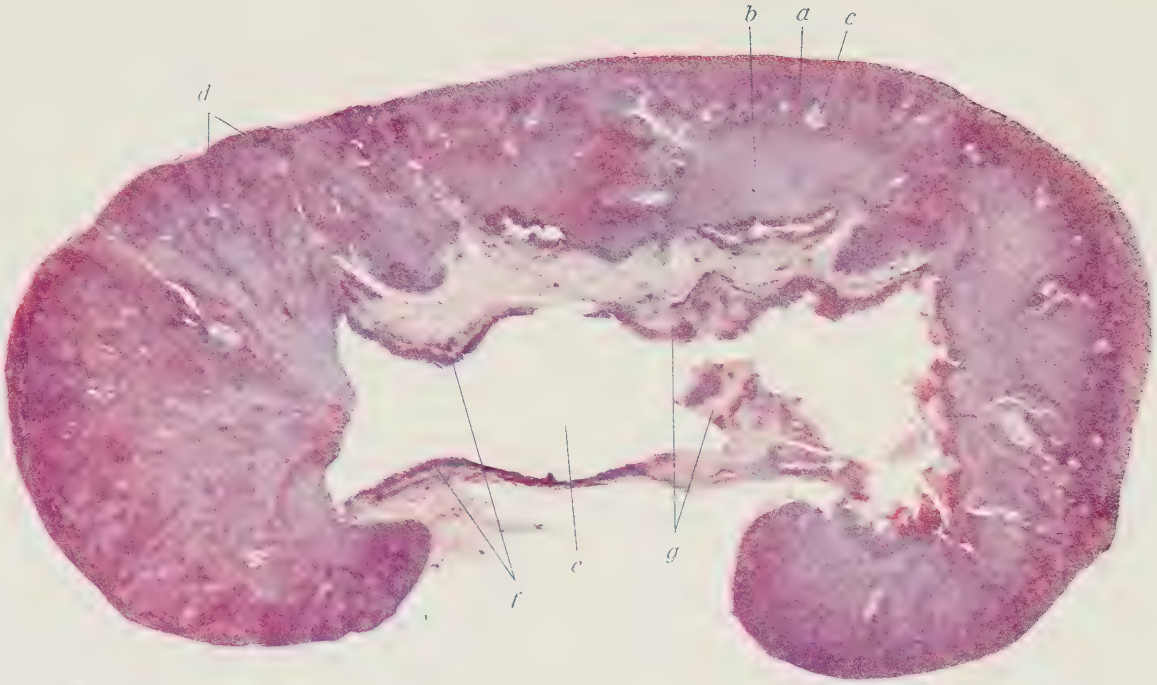
back of the neck being an exceedingly common original focus, whence the organisms are carried to the kidney by way of the blood stream. Sometimes a history of boils may be obtained from the patient, but more often the original focus appeared so long before any kidney difficulty was manifested, or the external lesion was so insignificant that the patient has forgotten it entirely, so that this very important link in the chain of diagnostic evidence will be lacking. But if the patient has a high temperature suggestive of sepsis, when blood examination reveals a marked leukocytosis, and palpation of the renal region shows that the kidney is enlarged and sensitive to pressure; if the examiner can elicit a history of recent furunculosis, a carbuncle on the neck, or a felon on the hand, there is good reason to suspect the presence of a renal carbuncle.

Symptoms and Diagnosis.—Accurate preoperative diagnosis will often be impossible. Urinalysis is frequently of no help whatever. Sometimes staphylococci and pus may appear in small quantities in the urine, but in most cases the findings will be practically negative.[8, 28] The symptoms will be those of an acute infection, leukocytosis and high temperature, great prostration and weakness, and occasionally, septic chills. Palpation over the affected kidney will reveal great tenderness, and usually, enlargement can be readily made out. There is always some pain, but this may be much less intense than the severity of the condition would seem likely to produce. Renal carbuncle usually gives more resistance and fixation on palpation than is the case when small multiple abscesses of the kidney are present.[54] It seems probable that a condition beginning as a typical carbuncle may eventually involve the entire kidney in the suppurative process, thus producing either solitary or multiple abscess formation, so that the one form merges into the other.

Treatment.—When the diagnosis is established nephrectomy will usually be the only form of treatment possible, as these patients seldom come under observation until the process is too far advanced to make more conservative measures permissible. If the surgical intervention takes place at an early stage, it may be possible to do a nephrotomy and establish adequate drainage, but this is not often the case, and even when partial excision has been practiced at first, subsequent nephrectomy is usually necessary.[32]

Renal Tuberculosis.—Tuberculosis of the kidney while it is a steadily progressive affection, is usually of slow development, and is subject to long periods of remission, so that patient and physician alike are not infrequently deceived into believing that the process has permanently subsided. This form of tubercular infection is observed twice as frequently in males as in females, in patients between twenty and forty years of age,[14] and perhaps in three-quarters of the cases, there will be tubercular foci elsewhere in the body. Even when no active lesions are present in the lungs or elsewhere, healed foci can usually be detected upon careful examination. It appears doubtful therefore, if primary

PLATE XII



Early Tuberculosis of the Kidney.

Longitudinal microscopic frozen section after the method of Christeller. This section shows rather early tuberculosis, both parenchyma and pelvis being affected. There are many normal areas however. *a*, Cortex; *b*, pyramids; *c*, arteria arciformis; *d*, tubercular lesions in the parenchyma of the kidney—it will be noticed that the pathological lesions occur largely at the poles, the median portion being fairly normal; *e*, lumen of the pelvis; *f*, thickened infiltrated mucous membrane; *g*, caseous tuberculous masses in the kidney pelvis.

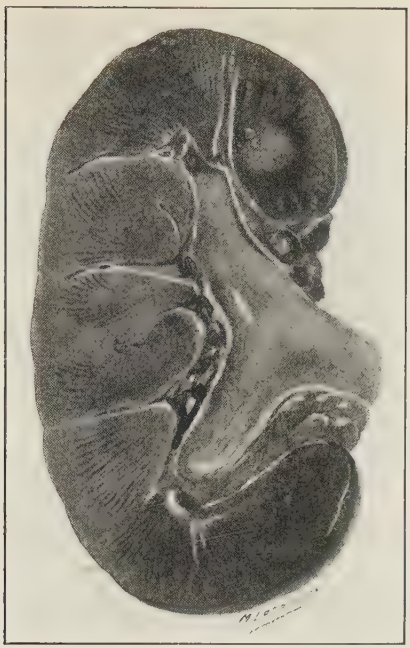


FIG. 195.—Renal tuberculosis. There are small groups of tubercles in the upper and lower poles of the kidney, with a few isolated ones in the median portion. This is a particularly early specimen.

FIG. 196.—Very early tuberculosis of the kidney. The specimen shows only a few patches of small tubercles.

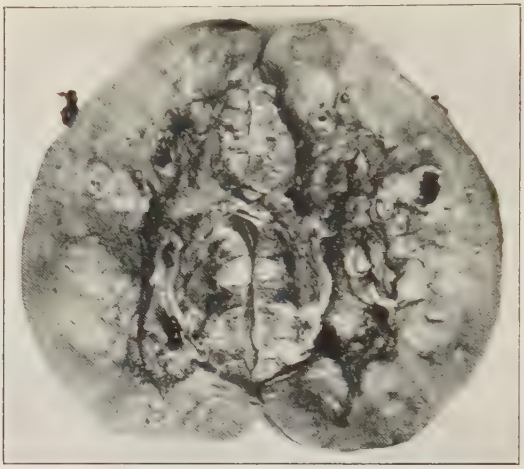
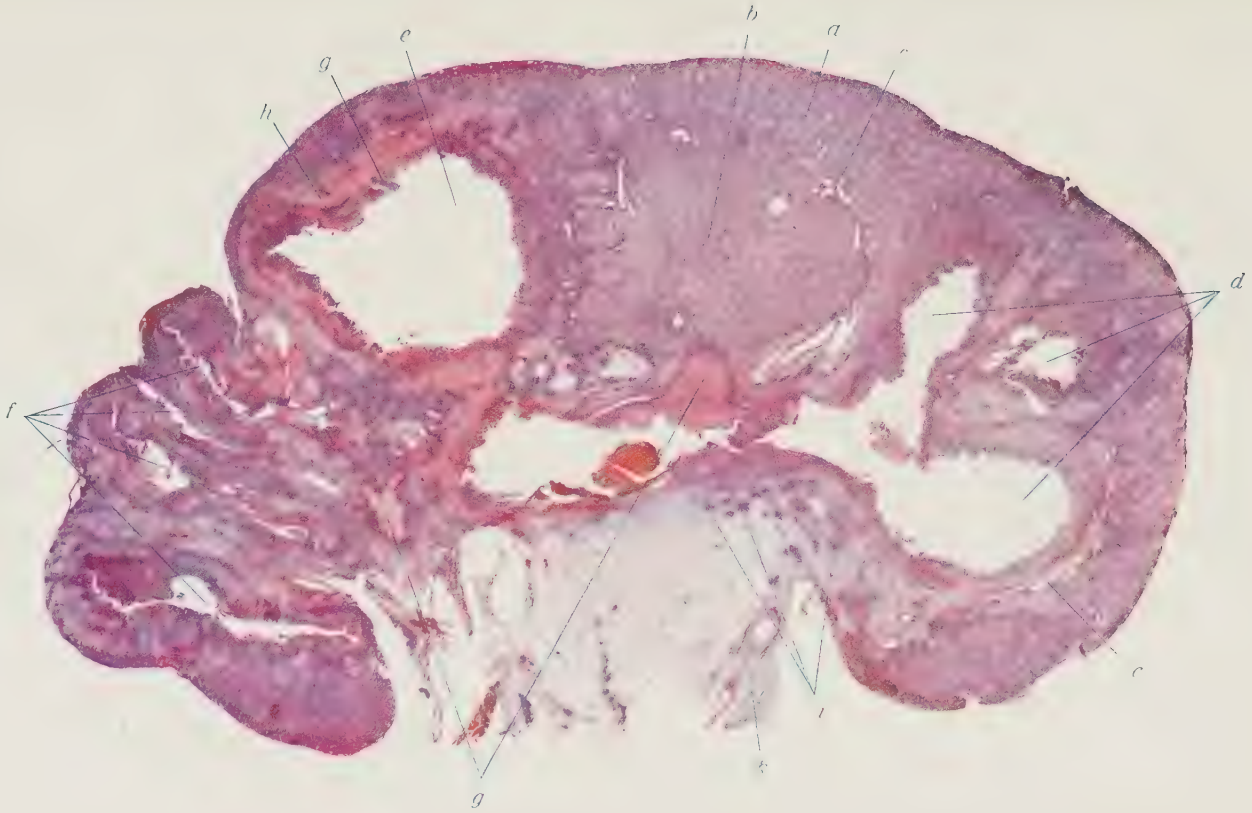


FIG. 197.—One small healed tuberculous abscess is shown in this otherwise normal kidney. The wall is infiltrated with salts, which cast a shadow in the roentgenogram. This is the sort of finding which encourages us to feel that if patients who have bilateral tuberculosis of the urinary tract are given the same sort of intelligent general care accorded to cases of pulmonary tuberculosis, a fairly large number of successful cures may be brought about.

FIG. 198.—Renal tuberculosis. Moderate involvement of the pelvis. There are a few tubercles seen in the upper pole. The remainder of the cortex is apparently normal.



Longitudinal Microscopic Frozen Section of Tuberculous Kidney.

Prepared and presented to the authors by Prof. E. Christeller for use in this text-book. This is an advanced stage of renal tuberculosis with abscess formation. *a*, Cortex; *b*, pyramid; *c*, arteria arciformis; *d*, ulcerated calyces; *e*, cavernous destruction of parenchyma; *f*, collapsed cavernæ; *g*, caseous pyelitic masses; *h*, tuberculous granulation tissue; *i*, nodular infiltrates (lymphatic tissue) in the pelvic connective tissue; *k*, renal artery.

renal tuberculosis ever occurs, although it is impossible to prove that it does not. The route of infection is probably similar to that followed by the other infective organisms which have already been mentioned, possibly ascending in a few instances, but in the great majority of cases of hematogenic origin.

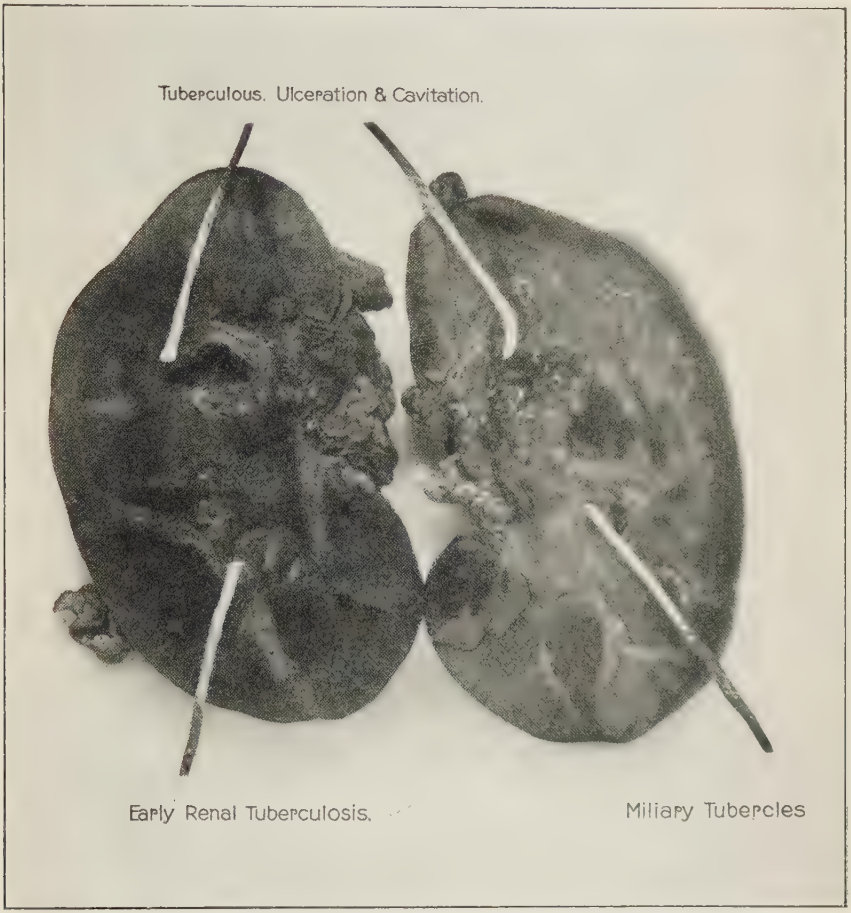


FIG. 199.—Several processes of the disease are noted in this specimen. These vary from early miliary tubercles to advanced cavity formation.

While there are several types of tubercular involvement of the kidney which are often observed in the advanced stages of pulmonary tuberculosis, in speaking of renal tuberculosis we generally intend to indicate the form which is characterized by a slow infiltration of the parenchyma by minute foci of infection which tend to coalesce into circumscribed tubercles, or masses which after gradual softening,

ulcerate and undergo caseous degeneration. This process is almost always unilateral at first, and in its early discovery and extirpation lie the patient's only hope of cure.

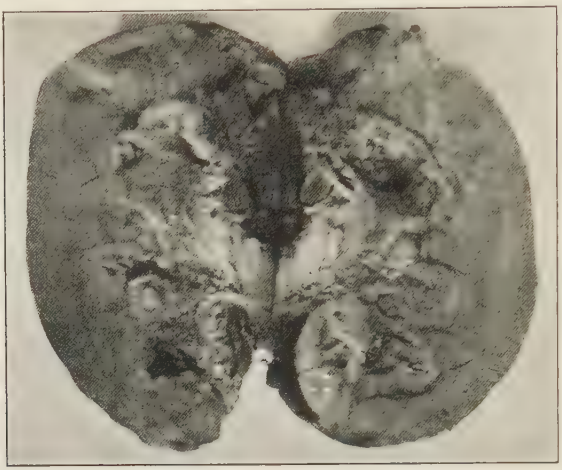


FIG. 200.—Renal tuberculosis. Advanced tuberculosis of the entire pelvis of the kidney, the cortex being almost entirely free from the disease.

FIG. 201.—External view of a tuberculous kidney in which the poles are comparatively free of the disease, but the middle portion shows a large tuberculous area.

Symptoms.—It is highly probable that a tubercular infection may remain latent in the kidney for a very long time without producing any symptoms whatsoever, and it is a common observation that those manifestations which appear earliest are usually referred to the bladder. Frequency of urination, especially at night, polyuria and vesical tenes-

mus are the earliest evidences of disturbance in the urinary tract. Pain is not a prominent symptom in any chronic renal infection, for slow distention of the kidney, even if quite marked, is rarely attended

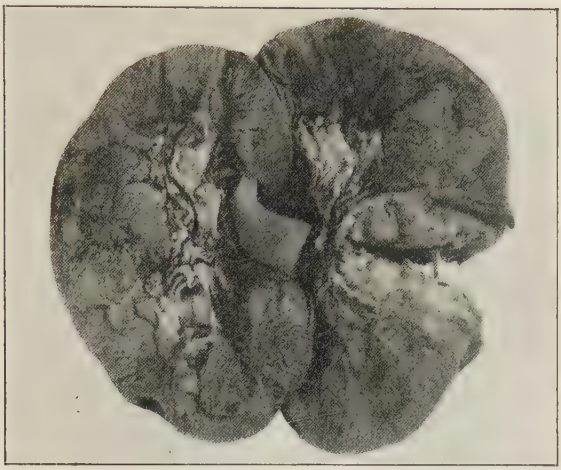


FIG. 202.—Renal tuberculosis. This specimen has an area of tuberculosis in the cortex of the median portion of the kidney. The entire focus is about the size and shape of a golf ball, and is here shown split open. It was apparently unconnected with the pelvis of the kidney.

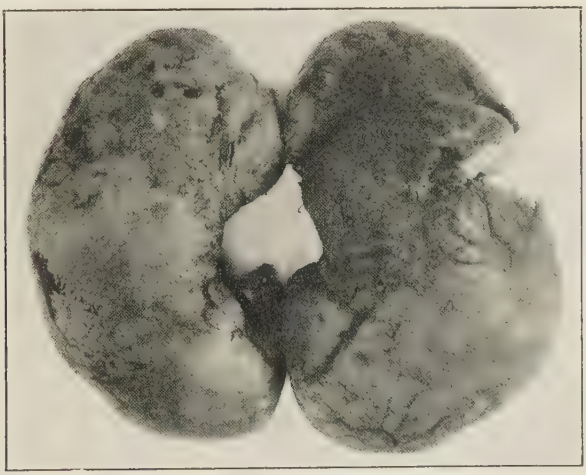


FIG. 203.—Renal tuberculosis (localized). Outside view of specimen in Fig. 202.

by acute pain, the kidney apparently having time to adjust itself to the changed relations; only those conditions which put sudden tension upon the kidney capsule cause renal pain.[18] Therefore until the tubercular process has progressed far enough to put tension upon the renal

capsule, it will cause no pain, and unless a caseating focus breaks down and discharges its contents into the renal pelvis, there will be no evidence to draw attention to the kidney. At an early stage however, the urine will be cloudy, and of light specific gravity, and if care-

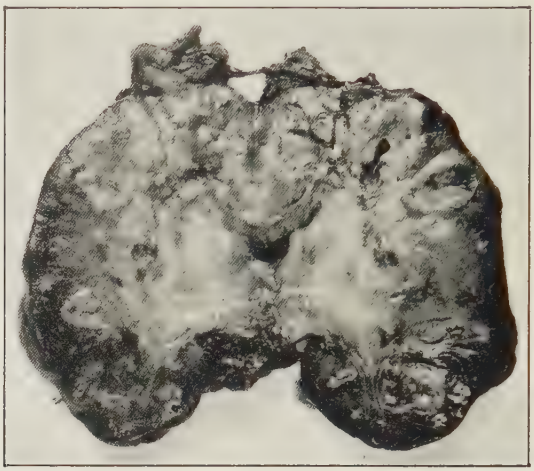


FIG. 204.—Renal tuberculosis. This specimen shows a large amount of fatty degeneration of the kidney in the region of the pelvis.

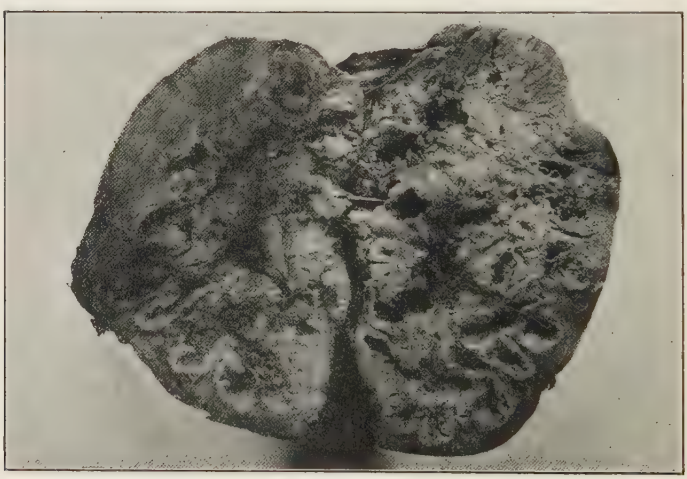


FIG. 205.—Renal tuberculosis. Multiple abscesses of the kidney, with well-defined fibrous walls. There is a small rim of functionating cortex remaining.

fully and repeatedly examined it will not be long before the tubercle bacillus can be detected in the sediment. Here also, shreds of detritus will be found, which upon microscopic examination will prove to contain connective tissue fibers. Occasionally there will be hematuria,

but it is usually slight and intermittent, and is so frequently entirely absent that its detection is not of great diagnostic importance. Even when there is sufficient hemorrhage to alarm the patient and send him

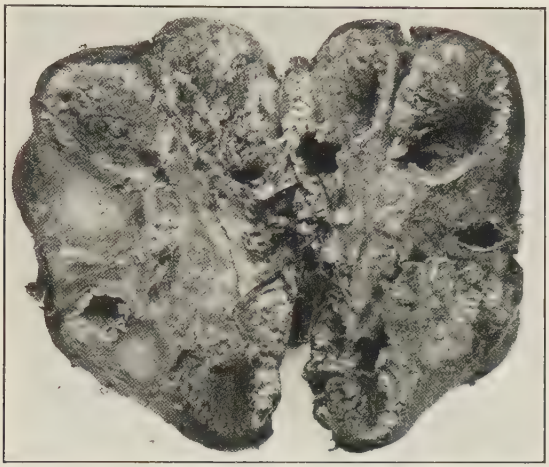


FIG. 206.—Advanced tuberculosis of the kidney, showing many abscess cavities filled with tuberculous granulation tissue.

FIG. 207.—Renal tuberculosis. This specimen shows a large number of tuberculous abscesses, with great destruction of the kidney. There is only a small rim of functionating renal tissue seen at the upper pole of the kidney.

hurriedly to seek medical assistance, the diagnosis will in most cases be left in doubt, unless careful examination is made of the entire urinary tract. In men especially, this should never be omitted, as the relation

between renal tuberculosis and that of the genital tract is very close indeed. Involvement of the genitals was present in at least 73 per

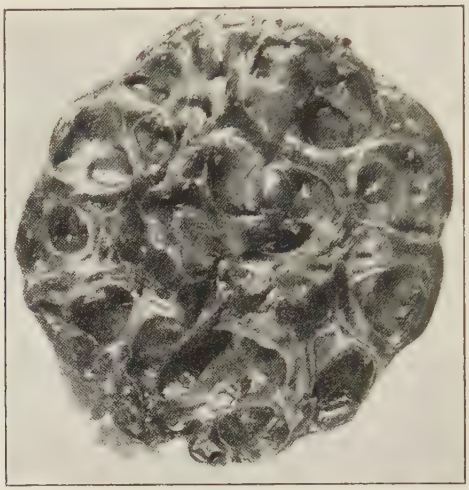


FIG. 208.—Renal tuberculosis. This is a case of autonephrectomy. The kidney is a mere shell, the major portion of the organ being excavated and filled with watery pus and caseous material thrown off by the disease process. This is the last stage of renal tuberculosis.

FIG. 209.—Marked tuberculosis of the kidney. A large abscess cavity is seen in the upper pole. The remainder of the organ shows much granulation tissue, several areas walled off thoroughly, and other evidence of Nature's attempt to heal the process.

cent of Braasch's male patients[14] and our experience has led us to believe that this may be regarded as a very fair average. (See section on Tuberculosis of the Seminal Tract, page 290). In the words of

MacGowen: "Be suspicious of every case of prolonged vesical irritation the origin of which is not entirely clear, for therein a renal

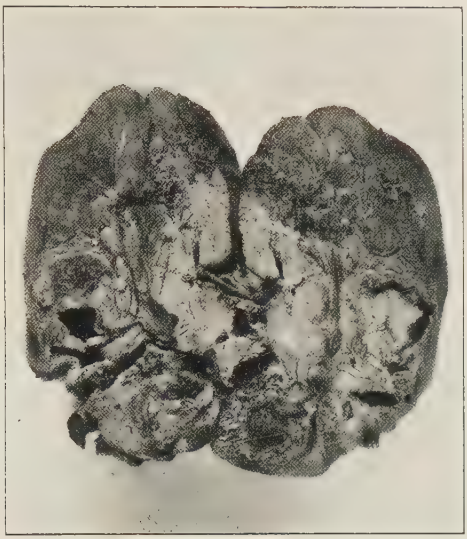


FIG. 210.—Renal tuberculosis. This specimen shows advanced tuberculosis of the lower half of the kidney, the upper half being comparatively free from the disease.

FIG. 211.—Long-standing tuberculosis of the kidney. The multiple abscesses here shown are walled off quite thoroughly in Nature's attempts to heal the lesion.

tuberculosis may be ambushed, a chronic infection, slow in its development, progressive, involving finally the entire urinary system, and mercilessly fatal, more important by reason of the fact that from its

anatomical peculiarity early skilful surgical aid will effect a permanent cure in more than 50 per cent of the cases."

Cystoscopic Appearance. The mucous membrane about the neck of the bladder and the trigone will be edematous, and in many cases ulcerated as well, and about the trigone there will be a peculiar injected appearance to the lining mucosa which has been described as looking as if finely powdered paprika were blown with great force into it. There may be evidences of ulceration about the orifice of the ureter on the affected side, but its appearance will not vary from that observed in several other vesical affections. There may be constriction of the orifice with ballooning out with each evacuation of urine through the ureter. Ureteral catheterization should always be practised if possible, and if the condition of the mouths of the ureters make this inex-

FIG. 212.—Atrophied kidney with no function, which shows many thoroughly walled-off tuberculous abscesses, the main bulk of the kidney being composed of fibrous tissue.

pedient or impossible, exploratory examination may be necessary. The decision as to which is the diseased kidney is naturally of the utmost importance, and the examiner should not rest until he has exhausted every resource. Guinea pig inoculation is one of the most satisfactory methods of discovering the presence of the tubercle bacillus in urine (see page 69).

Gonococcic Infection.—Gonorrhea is such a prevalent disease and non-gonococcal infections of the kidney are so often encountered that it is surprising that the gonococcus plays such an insignificant role in renal diseases.[87] The fact remains, however, that gonococcal infection of the kidney is unusual. Simmons[80] after a careful review of the literature states that only 24 cases of proven gonorrheal infection of the kidney have been put on record. The demonstration of the gonococcus by staining or cultural methods in material obtained

directly from the kidney pelvis or kidney substance is the only satisfactory method of definitely diagnosing gonorrhea of the upper urinary system. It would seem that the fact that so few kidneys infected by the gonococcus come to operation, indicates either that the symptoms of the infection are so mild as to demand little or no treatment, yielding readily to palliative measures, or else that it may spontaneously subside.[6] It is the opinion of Hagner,[40] while concurring with the prevalent conception that the gonococcus is more apt to prepare the renal tissue for infection by other organisms by lowering its resistance, than to be itself the direct cause of pyelitis, that nevertheless, a more thorough examination of the urine by separate catheterization of each ureter in cases of chronic pyuria associated with chronic gonorrhea will lead to a more frequent demonstration of the gonococcus alone as the causative agent in pyelitis.

Symptoms.—The clinical picture can hardly be differentiated from that of infection by other organisms. In one reported case[15] the lesions in the bladder and about the ureteral orifice simulated those of tuberculosis; there was marked thickening of the ureter, with periureteral inflammation such as might be induced by the presence of a calculus. The kidney in this case was anomalous, being double with two ureters and two ureteral orifices on the right side of the bladder. The upper part of the double kidney was practically normal, but the lower part, which had a completely separate renal parenchyma, pelvis and ureter, presented a typical infected hydronephrosis, except that the area of renal cortex which capped the much larger distended pelvis was of very small size. The pelvis was enormously dilated, pyriform, greatly thickened and edematous on the outside, and covered by frail adhesions. It was practically a pear-shaped sac, part of the wall of which was made up of greatly attenuated parenchyma, showing the usual atrophic appearance.

In an earlier reported case[60] postmortem examination showed the right kidney to contain suppurating cavities, averaging about the size of walnuts. Arising in the renal pelvis and the collecting tubules, the infection had spread to the intermediary zone, gradually absorbing the excretory structures, but only indirectly affecting the secretory portion. The ureter was also thickened and dilated, and filled with pus, which, like that obtained from the kidney tissue, yielded a pure culture of gonococcus.

Diagnosis.—The diagnosis must rest upon the isolation of the gonococcus in the urine from the affected side, and can only be suggested by a history of previous gonorrheal urethritis and cystitis. Mixed infections will be most frequently encountered; in fact, it will be a very exceptional case, in which the gonococcus alone can be proved responsible for the infectious process which has invaded the kidney.

Perinephritic Abscess.—Perinephritic suppuration is usually an extension to the perirenal fat of a pyelitis or other infectious process within the kidney, such as arises from the presence of calculus, from a

tuberculous process, or abscess formation secondary to a focus elsewhere in the body. Less frequently a suppurative process in the perirenal fat may be an extension from without, having its origin in an appendicitis, a pelvic visceral inflammation (in women) or a focus of infection in the tissues adjoining the bladder and prostate. The lymph channels may also convey infection thither from a cholecystitis or hepatic abscess, or a condition of ulceration in the upper alimentary tract.

Thus occasionally the perinephritic invasion may be primary, the kidney remaining healthy, but it is much more likely to be secondary to renal disease, or infection in some contiguous organ.

Symptoms and Diagnosis.—In those cases where there has been no preceding renal disturbance, the first indication of perinephritic suppuration may be a chill, followed by rapid rise of temperature and other indications of abscess formation, with tenderness on palpation and pain referred to the loin and sometimes reflected to the thigh or the scrotum. The blood findings and temperature curve will be those which accompany suppurative processes in other locations. If the process is secondary to pyelitis, tuberculous or otherwise, to renal calculus, or to disease of the pelvic viscera, the first indications of perinephretic involvement will be the localized pain and tenderness, with subsequent evidences of pus collection such as fever and leukocytosis.

One element of confusion which may arise when no systematic blood count is taken, is the apparent involvement of the hip. The reflected pains already mentioned may irritate or possibly actually involve the psoas muscle, producing flexion of the thigh, making voluntary extension painful, if not altogether impossible, and the pain is not infrequently reflected as far as the knee, so that the examiner's attention may be drawn so strongly to the hip, as to overlook signs directing it to the renal region, and the real nature of the trouble may not be recognized until it is possible to elicit fluctuation in the loin.

In most cases the progress of a perinephritic abscess is rapid, although the exact location of the pus collection has much to do with the promptness with which its existence may be recognized. Its most common situation is behind the kidney, extending toward its lower pole, and when so placed the swelling and fluctuation in the renal area will soon be apparent. If the pus collects nearer the upper pole of the kidney, the symptoms will be similar to those of a subphrenic abscess, for diaphragmatic excursion on that side will be considerably limited. Alimentary symptoms, such as obstinate constipation, nausea, vomiting and, less frequently, jaundice, are likely to arise when a perinephritic abscess lies toward the upper pole of the kidney. But whatever its situation, the most marked and characteristic symptom is the local swelling, which is always retrorenal and distinctly separated from the abdominal parietes, is quite uninfluenced by respiration, and can be readily differentiated from swelling of the kidney proper by its diffusion

and the absence of sharply-outlined limits of extension. If allowed to progress without intervention of any kind, a large amount of pus may collect, so that the swelling may be visible all the way from the diaphragm to the groin, running laterally as far as the mid-line, while the skin above it will be inflamed and edematous.

Evacuation of the pus, if left to Nature, will usually take place through the loin, but often not before the pus has had time to burrow down toward the groin, or upward in the direction of the diaphragm. Sometimes the abscess will open into the renal pelvis, or an adjacent loop of intestine, or rarely, as in the case of some hepatic abscesses, into a bronchus. In any event a discharging fistula is likely to remain, and recovery is very protracted, if peritonitis does not bring about an abruptly fatal termination.

Surgical evacuation is indicated as soon as the presence of pus can be established. When the abscess is being emptied, it is well to expose and examine the kidney if this can be done without injury to the capsule, as a calculus may thus be discovered, or other involvement of the renal tissue proper be made manifest. In general, the condition of a patient suffering from one of these abscesses is so grave, that any intervention upon the kidney is contraindicated, and should renal surgery be necessary, it will usually have to be deferred until the acute perinephritic condition has somewhat abated.

Pyelonephritis.—Pathologically, hematogenous pyelonephritis which at first involves only the renal parenchyma, is evidenced by multiple tiny abscesses of the cortex, so that the kidney surface presents an irregular and roughened appearance. Later these original foci will coalesce, so that even if the medullary portion does not at first participate in the infection, it soon becomes involved, and the pelvis is likewise eventually infected. Sometimes a single abscess may be formed by a large solitary infarct.

When the infection is of the ascending type there will usually be a preliminary distention of the pelvis, whence the infection travels to the pyramids, setting up numerous areas of suppuration which later coalesce, the entire kidney often becoming a pus sac, which in rare cases has been known to calcify. If the infection has gained a foothold through trauma, as for example, when the tissues have been injured by a rough calculus, the area of suppuration will be confined to the injured portion alone, and a solitary abscess will result.

Pyonephrosis.—Pyonephrosis is due to a dilatation of the calyces and pelvis of the kidney with pus, or sometimes a combination of pus and retained urine. Often dilatation and the suppurative process may have advanced coincidentally, for if infection be introduced where a uro-nephrosis already exists, pyonephrosis may be set up at any time. Thus if an ulcerative ureteritis is present which is sufficient to produce destruction, or if a stone or the detritus cast off by a tuberculous process should bring it about, pyonephrosis is an almost certain sequel when infection can take place. Right-sided pyonephrosis is

not an uncommon complication of pregnancy, usually occurring about the fifth month of gestation.

Pyelitis.—The onset of acute hematogenous pyelitis is usually evidenced by chills and a rapid rise of temperature, with the appearance in the urine of pus, bacteria and a few red blood cells. Urgency and frequency will be noted, and on palpation considerable tenderness can be elicited over the affected kidney. If the parenchyma as well as the pelvis is affected, the symptoms will be proportionately more intense. In general, the initial symptoms of an ascending infection will be much more severe, often presenting rigors, high fever and a tendency to collapse. Any kidney infection may run a more chronic course, giving the manifestations common to any form of suppuration, with remittent chills and fever, and more or less tenderness in the affected area. Pyonephrosis runs a more protracted course than suppurating pyelonephritis, an additional symptom being the invariable presence of a tumor mass in the region involved, which however, may vary greatly in size in different cases, or even in the same patient at different times. At irregular intervals there may be large discharges of pus through the ureter, which will bring about a marked remission in the symptoms.[22]

It is frequently impossible to do more than infer with reasonable probability the cause of a renal suppuration, and there is often no way to decide whether the abscess lies in the kidney pelvis, or whether the parenchyma also has a share in the infection. But there can be no doubt that if left untreated, such a focus will quickly involve the tissues adjacent to it and soon cripple, if not actually destroy, the entire organ, and more than likely will eventually prove a source of contamination to the rest of the urinary tract. An untreated renal abscess has every likelihood of bursting through the kidney capsule, causing perinephritis and involvement of the colon, and sometimes even of the adjacent lung and pleura.

Treatment.—Surgery offers the only safe and reasonable treatment. As with any other abscess, the pus must be evacuated, which can usually be accomplished by cutting down upon the kidney through a lumbar incision, and in severe cases, some remarkable results have followed splitting the entire organ. Primary nephrectomy is indicated in pyonephrosis when there is a sound opposite kidney and when inspection of the pus sac shows many or large pouches which cannot be successfully drained; when but little actual kidney tissue remains, or examination of the pelvis and the proximal portion of the organ gives reasonable certainty that a return to normal cannot be anticipated; or if perinephritic suppuration has taken place, in which case the kidney may act as a valve which impedes successful drainage.[74]

Hydronephrosis.—A tumor in the kidney region which is apparently due to the accumulation of fluid and suggests a slowly-forming pyonephrosis, may attain a large size yet give none of the constitutional symptoms which have been enumerated as indicative of kidney sup-

puration. In the absence of any such symptoms, with a soft, elastic or definitely fluctuating tumor, we are likely to be dealing with a

FIG. 213.—Infected hydronephrosis, with dilatation of major and minor calyces, distortion at the uretero-pelvic junction and dilatation of the ureter. There is a stone in the lower third of this ureter which is apparently the cause of all of the lesions present.

hydronephrosis. Hydronephrosis results from obstruction which produces dilatation of the pelvis and calyces of the kidney with coin-

cident atrophy of the kidney substance. Such obstruction may be either congenital or acquired. In the congenital form it may be occasioned by anomalies in the position of the kidney causing kinking or contortion of the attached ureter, or an abnormal high insertion into the kidney pelvis brings about a condition of partial obstruction with resulting retention. If the kidney is even slightly movable and has in addition an anomalous renal artery such as has been heretofore described, should this artery be distributed over the anterior portion of the lower pole, it may give rise to a hydronephrotic condition, by compression of the ureter.

Obstruction can take place from a number of acquired causes, the most common of which are impacted calculus, prostatic hypertrophy, ureteral stricture, phimosis, tuberculosis, or neoplasms. In women, tumors of the ovaries or uterus frequently induce hydronephrosis, but second only to pelvic tumors; movable kidney, a condition observed more frequently in females than in males, may be held responsible for urinary obstruction. Intermittent hydronephrosis is practically always due to the migrations of a movable kidney, which at times causes its ureter to kink, and then, by a return to its normal position, to straighten out again, so that the obstruction is, temporarily at least, relieved. Some authorities believe that the mobility of the kidney results from its distention, instead of being the occasion of it.

Partial Obstruction.—Most frequently the entire kidney will be distended, but in anomalies such as double ureter, or in the presence of tumors or impacted calculi, the distention may be only partial. It must be remembered that the condition is due to a *partial* blocking of the normal outlet; when complete suppression takes place the kidney will usually undergo atrophy without any perceptible dilatation. Partial blocking of the ureter on the other hand, will permit the urine to pass out very slowly, and as the pressure in the kidney is lowered, more urine will be secreted, thus subjecting the kidney to constantly recurring pressure. When such pressure is constantly exerted for a long period the renal tissues will gradually give way, until nothing remains but the sac filled with fluid which is characteristic of the hydronephrotic kidney. If infection gains an entrance to the sac, pyonephrosis will result. This is very likely to occur if the obstruction has been due to the presence of an impacted calculus in the ureter. As such a calculus undoubtedly had its origin in the kidney, and a kidney which produces stones cannot be healthy, and should therefore, be peculiarly prone to infection, the etiological sequence in these cases is very easily explainable.[19]

Course.—Very frequently however, a hydronephrosis will for a long time pursue an entirely aseptic course, giving rise to no symptoms whatever, until it has produced a tumor of considerable size. Sometimes, but by no means regularly, a dull intermittent pain will be complained of by the patient, but the urine which is voided will, in most cases, be apparently normal, exhibiting no evidence which would

point definitely to the condition actually existing. Profuse but painless hematuria may occasionally be seen, usually following a long period of occlusion, which may have been previously evidenced by renal colic.

Diagnosis.—Aspiration of the cyst is the most common way of determining the nature of the tumor; but of recent years exploratory incision has frequently been made, although a careful cystoscopic examination combined with ureteral catheterization should, except in most obscure cases, serve to establish the diagnosis.

Treatment.—Though there is little doubt as to the advisability of removing a kidney which has been metamorphosed into a fluid-containing shell, the recuperative power of renal tissue is well known to be almost miraculous, and nephrectomy should only be performed in the most advanced conditions; and then only after a serious consideration of all other factors. The functional capacity of the distended kidney should in all cases be accurately established before any steps toward its removal are taken. If nephrectomy can be avoided, the operative intervention should be for the removal of the cause of obstruction, whatever that may have proved to be, after the hydronephrotic sac has been opened and evacuated.

RENAL CALCULUS.

Etiology.—There are a number of theories concerning the formation of renal calculi, but the subject is still somewhat obscure. One of the most common beliefs is that each stone is formed upon a nucleus of some organic substance, desquamated cells, bacteria or possibly pus, upon which urinary salts are deposited; another theory which has many adherents postulates that some colloid ingredient of the urine, most likely albumin, collects crystals which are deposited by supersaturated urine. An examination of the statistics which have been gathered in regard to renal calculus seems to point to the fact that certain kidneys are predisposed to stone formation. It has been well established that the presence of infection is not necessary for the formation of calculus in the kidney. It seems likely however, that the retention of urine within the kidney pelvis may have an important bearing on the formation of stone. One eminent authority believes that stone formation is the result of the combination of two types of bacteria; the first creates an infarction with minute areas of necrosis from which a mucoid exudate is given off; the second factor is the elimination at the same time of stone-forming bacteria, so that they come in contact with this mucoid exudate. Though stones form in the cortex, the calyces and the renal pelvis, their rate of growth will be greatly influenced by the situation in which they originate. A calculus which takes its rise in the cortex will grow slowly, but because the substances which increase its size are more abundant in the calyces

and pelvis, a stone initially arising in one of these two locations will grow with far greater rapidity.[64]

It has been pointed out[82] that if stone is due to a local mechanism at work in the kidney, then an increased elimination of uric acid, or of oxalate or phosphate would probably enhance the chances of lithiasis by furnishing a more abundant supply of the material of which the stone is composed. The evidence brought forward for diet as a cause of calculus is at best inconclusive. Calcification in necrobiotic tissues, metabolic errors, neuroses, sedentary habits, all have been accused as causal factors, but without convincing proof of their guilt.[52]

The basis of the "anatomical" or "mechanical" theory of calculus formation is the apparently frequent association of stones with anomalies or pathological states such as urinary stasis, or diverticula, enlarged prostate, stricture or other cause of obstruction. The common observation of renal infection in conjunction with stone has given rise to the "bacterial" or infectious hypothesis.

Focal Infection.—Recent work on focal infection has shown that an important relation undoubtedly exists between infection arising in other parts of the body, and the formation of renal calculus. Rosenow and Meisser[75] infected the teeth of previously healthy dogs with streptococci from the urine, infected teeth and tonsils of 9 patients suffering from typical nephrolithiasis, and succeeded in producing calculi or lesions of the medulla in 87 per cent of the animals so infected. The experimentally produced calculi were similar in physical properties and chemical composition to those found in nephrolithiasis in man, the number and size of the stones being often in proportion to the length of time the experiment was allowed to continue. Other urinary tract findings closely resembled those observed in human patients suffering from this disease.

The results of these studies seem to emphasize very strongly the part played by focal infection in the etiology of renal stone, and also to suggest that a stone-forming infection might possibly account for the high incidence of renal calculus in certain geographical locations.

Chemical Composition.—A study of uric acid stones was made by Shattuck, who found that organic nuclei were very rare, the center being practically always a primary crystalline deposit. Of 545 calculi which were examined by Utzmann, 80.9 per cent had nuclei formed of uric acid, and the same kind of nucleus was found in 158 of the 187 stones which Henry analyzed.[81] But although uric acid seems to be a very frequent substance serving as a nucleus, it is nevertheless, not a large component of the commonly found renal calculus. In most of the analytical reports it is noted as forming but from 2 to 10 per cent of the entire substance of such stones. According to Wells, oxalate stones are the most prevalent, and in George Gilbert Smith's series of 34 cases, the stones in 16 were composed largely of this substance. The constituent next in frequency is phosphate, combined with ammonium, calcium or magnesium. The phosphates

of these elements which are excreted in the urine, are the salts which go to make up phosphatic calculi. As the phosphates of the alkali metals such as sodium or potassium are soluble, they do not take part in stone formation. Exceptional stones are found of which the main constituents are pure urate, cystine, calcium carbonate and xanthin. It is pretty generally conceded that the nucleus of renal stone early in life is ammonium urate; in young adults, it is more likely to be uric acid; while in elderly persons, calcium oxalate is the most common. In all types of renal stone the percentage of oxalate is apt to be high.

It has been shown that differences of reaction as determined by the hydrogen-ion concentration and qualitative and quantitative changes in the colloidal materials of the urine, such as pigments, mucin, nebecula, albumin and nucleo-albumin, influence the nature of urinary sediments both chemically and physically; and examination of the calculi, both with and without the microscope, seems to show that an abnormal variation of these factors operates in calculus formation.

After extensive studies on the etiology of urinary calculus, Keyser[51] reached the conclusion that calculus formation is due to a disturbance of the normal colloidal mechanism of the urine, either in holding water-insoluble materials in solution, or in precipitating crystals as isolated entities. This disturbance may be due either to changes in the colloids normally present in the urine, or to invasion by abnormal colloids, either from the blood stream or more probably as products of disease local to the kidney. Not every abnormal colloid introduced into the urinary outflow will be associated with atypical crystalline deposits or stone-formation, for otherwise stone would be constantly associated with nephritis and pyelitis, which we know is not the case. Therefore the stone-forming colloid must be specific, and if due to bacteria, the bacteria which produce it must be specific.

Cystine Nephrolithiasis.—Cystine nephrolithiasis although a rare condition, has received a good deal of attention during the past few years.[16] The etiology of cystine calculi, like that of others, is uncertain, but the consensus of opinion is apparently that their formation is made possible by some error in metabolism which involves certain of the end composition products of protein, cystine being the most important of these. It is possible also that there may be at the same time an inhibition of diamines, together with oxidization of some other amino-acids.[20]

Diagnosis.—The diagnosis in the case of pure cystine stones is rendered peculiarly difficult by the fact that not infrequently they cast no visible shadow in the roentgenogram. Certain observers have noted that cystine stones cast shadows and others are equally positive that they do not. This wide divergence of opinion may be due to a different arrangement of the molecules in the various specimens examined,[39] even when these different stones are formed from precisely the same elements, or there may possibly be a certain amount of

admixture of other salts in one specimen, which are absent from another.[21] If cystine can be detected in the urine, either in solution or in the form of crystals, the diagnosis of a cystine stone is strongly suggested. The passing of cystine crystals is often accompanied by renal colic and lumbar pain. But stones of this composition have been removed from the kidneys of patients whose urine never showed a trace of this substance.[9]

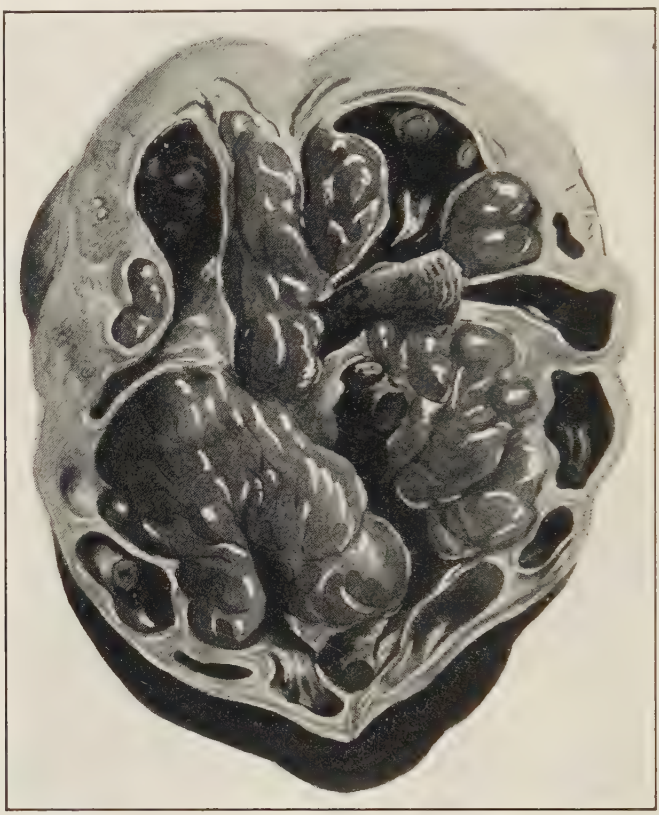


FIG. 214.—Multiple renal calculi shown in every portion of the kidney, which has very little renal tissue remaining. A large area of fatty degeneration is noted in the region of the kidney pelvis. This is the type of case in which the fluoroscopic examination of the Mayo Clinic or the roentgen-ray examination of Quinby, of Boston, after removal of the stones and before the repair of the body wall, is indicated.

Treatment.—It is advised by Crowell that if the stone is associated with cystinuria disintegration should be attempted by the internal administration of alkalies, pelvic lavage with alkaline solutions, and limitation of protein diet. These stones are so soft and brittle that their complete removal by pyelotomy is a difficult matter, and recur-

rences are very frequent, so that in the end the kidney will very likely have to be removed.

Opacity of Different Types of Calculi.—As diagnosis today depends in so great a measure upon radiographic findings, the question of relative opacity of renal stones becomes of great importance. In this connection the findings of the English radiographer, Winbury White are of especial interest.[92]

The relative opacity of calculi of equal depth depends upon the atomic or molecular weights of their constituents.

The opacity of a calculus is determined by: (1) The nature of its constituents; (2) its structure; (3) its thickness.

Calcium oxalate and calcium phosphate give very good shadows. They are very common constituents of urinary calculi. The high relative opacity is due to the high atomic weight of the calcium present in these salts.

All the other common urinary salts give relatively poor shadows. They include the urates, uric acid and triple phosphate.

Cystine and xanthine also give poor shadows in the pure state, but of slightly more opacity than the foregoing owing to the sulphur they contain.

It is rare for any of the foregoing substances to be the sole constituents of a stone. This applies to cystine as well as to the more common varieties. There is frequently calcium oxalate or phosphate present.

The figures of different observers giving the relative incidence of different salts in calculi have frequently been conflicting. Recent observers, however, are agreed upon the preponderance of calcium oxalate in renal and ureteric stones, and of uric acid and urates in bladder stones.

Phosphate is found in larger proportions as a constituent of bladder stone than of renal stone. It frequently surrounds a nucleus of oxalate, or uric acid or urates.

Stones of uric acid or urates in the kidney or ureter soon become mixed with calcium salts, after which they can be identified by radiogram.

Exploratory operation for stone is rarely justified when the radiogram is negative.

Radiograms sometimes fail to demonstrate vesical calculi consisting largely of uric acid or ammonium urate. Where possible, cystoscopy should always be carried out for this reason.

Influence of Age, Sex and Geographical Location.—Renal stone seems to be found most frequently in patients between fifteen and thirty-five years of age. Of Cabot's[16] series of 157, 56 were in the third decade, and Morris out of 188 patients had 54 in the third decade. These figures however, relate to the age when the cases came under observation or operation; symptoms with almost every patient began much earlier; a large number of cases undoubtedly begin between

the ages of ten and twenty years, the largest number is found between twenty and thirty years, and between ten and forty years, there occurred 120 out of 153 cases, while after forty years the frequency of occurrence of stone of sufficient size to require operation fell off very rapidly.

Males are undoubtedly much more subject to renal stone than are females. Cabot and Crabtree state that the ratio between the sexes is about equal, and Ransohoff in his contribution to Keen's *Surgery* makes a similar assertion. But at the Mayo Clinic there have been at least two males to every female,[12] and in our own experience males have greatly preponderated.

That the residents in certain geographical localities are peculiarly subject to renal calculus, has long been noted. We have already spoken of the great prevalence of all forms of calculus among the lower classes of Chinese (page 337). Statistics are frequently cited to prove that hard water is a potent factor in the production of renal stones, but though this certainly does insure a larger amount of calcium being taken into the system, it is doubtful if it has any bearing upon the production of kidney stone. It has been noticed that extremely cold regions such as the far North are peculiarly exempt, while certain warm countries, notably India and China, are apparently climatically suited for the production of this pathological condition.

Diagnosis.—The diagnosis of renal stone now depends almost wholly upon the results of functional tests of the kidney, the findings by the cystoscope and shadowgraph catheter, pyelography, and the results of regular roentgenographic examination. Often the roentgenographic examination alone will make the diagnosis positive, but not infrequently its auxiliaries, the shadowgraph catheter and opaque pyelographic medium, will have to be brought into play, especially when dealing with stones in the renal pelvis. The roentgenographic exposure should always include both kidneys and ureters; bilateral calculi are very common and there is always a possibility of stone being present in one kidney, with one or more stones in the ureter on the same or opposite side. Many times one kidney has been removed because of stone, and later the patient has returned with the same condition in the surviving kidney. Under such untoward circumstances it is of more than academic importance to ascertain whether the stone was present before the first operation, or whether it formed subsequently.[55]

The general application of roentgenography to renal diagnosis has been discussed elsewhere. Cystoscopy and ureteral catheterization will usually reveal the source of blood or pus which may be appearing in the urine, or if the calculus has produced a free hemorrhage, its origin can usually be discovered by their employment. If the stone is on its way downward through the ureter, the condition of the ureteral orifice on that side as it appears through the cystoscope, will be a ready diagnostic aid.

Pain, while present in the majority of cases, is not an invariable manifestation of the presence of renal stone. When it occurs it may be either a dull ache in the lumbar region due to distention of the kidney capsule from inflammatory swelling, or it may be a sharp pain, that of typical renal colic, often accompanied by nausea and vomiting, which is likely to radiate down the ureter to the bladder, or even as far as the external genitals.

Differential Diagnosis.—It must be kept in mind, however, that colicky pain radiating to the bladder or external genitals is not produced by renal calculus alone. Some other causes producing similar phenomena are the passage of clots which are induced by neoplasms, by the existence of granular pyelitis, or hematuria from some other cause; a "kink" in the ureter due to the mobility of a "floating" kidney; the expulsion of débris, pus or other excretions, cast off from infected areas produced by the tubercle bacillus or other infecting organism; strictures or inflammation of the ureter; or at times, the existence of a certain type of nephritis. The pain must also be differentiated from that due to cholelithiasis, calculi lodged in the pancreas, or the pains caused by inflammation of the appendix, or by intestinal obstruction.

It has been pointed out by Eisendrath[27] that a very frequent mistake in diagnosis is the failure to consider a tabetic crisis as the cause of an acute abdominal condition, such as ureteral colic. One should test the patellar reflexes and the accommodation to light in every case presenting the syndrome of ureteral colic, in order to avoid embarassing mistakes.

If there is a history of a pain, dull but persistent, which increases upon exertion, and the finding of blood or pus in the urine is coincident with it, it should be regarded as highly suggestive of renal calculus.

Silent calculi are however by no means unusual, and as our diagnostic technic attains a higher standard of perfection, the discovery of these symptomless intruders becomes constantly more commonplace. Often stones in one kidney will produce symptoms, while those on the opposite side will give no indication of their presence. This emphasizes the importance of extending the roentgenographic examination over the entire urinary system, and demonstrates the absolute necessity of giving every patient the benefit of all the diagnostic devices we can command.

Treatment.—There is no doubt that if a stone remains long enough in the kidney it will gradually reduce that organ's functional capacity and eventually destroy it altogether. Recurrence is very common after surgical removal of the calculus, and from a kidney that once becomes infected there will be a constant out-pouring of toxins which will be absorbed into the circulation to the continuous detriment of the entire organism. But generally speaking, if the presence of but one calculus has been demonstrated and its size is sufficient to make its spontaneous evacuation out of the question, it should be removed by operation.

Bilateral Calculi.—If there are stones on both sides, it is usually conceded that the functional capacity of each kidney should be carefully ascertained, and the stones removed first from the side which makes the better functional showing. Some authorities, however, dissent from this opinion,[38] claiming that this holds true only when one kidney is practically destroyed, and the other has fair or good function,

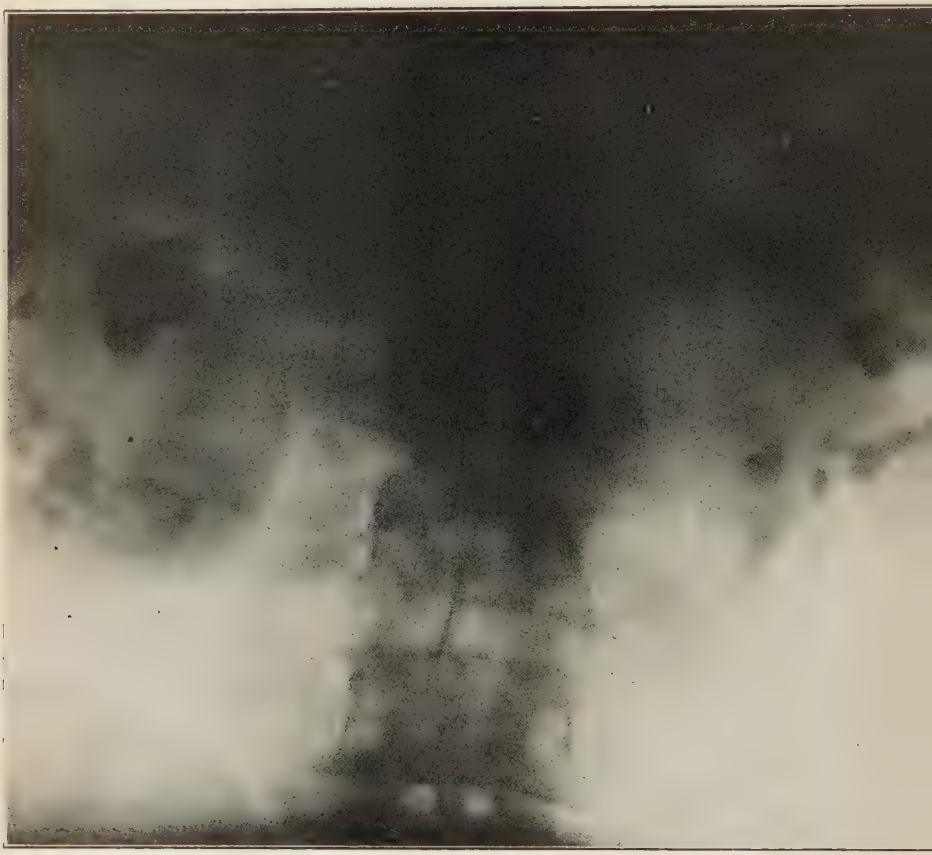


FIG. 215.—Roentgenogram showing bilateral calculus disease of kidneys. In such cases the surgeon is confronted with the problem of deciding whether to operate upon the good kidney first, or to follow the advice of Cumming, of Detroit, and remove the stones from the side with poorer function, so that it, upon recovery, will help sustain life while the good side is being repaired.

and that the real determining factors are the position of the stone and the degree of obstruction that it is producing. If, for example, on one side a stone is free in the pelvis and is causing intermittent blocking, or a stone is impacted at the uretero-pelvic junction with marked impairment of function, and on the other side a calculus may lie in the renal tissue at a point where it is not causing destruction of renal func-

tion, the indications are clear-cut to remove first the stone which is causing the rapid destruction of the kidney. In cases with an impacted ureteral calculus on one side, especially if associated with infection, and a renal calculus on the other, the ureteral calculus should be removed first, provided only one side is to be operated on at a time.

An extreme example of such a problem was the case of a patient seen by one of the authors, who was very properly described as a human rock quarry. Stones were present in both kidneys and both ureters. On the right side the ureteral catheter was stopped at about 2 cm. from the vesical orifice, and no urine could be obtained from it; on the left, however, the catheter passed to the pelvis and urine dripped freely from it. One cubic centimeter of phenolsulphonephthalein injected intramuscularly appeared on the left side in eighteen minutes. Roentgenography showed numerous large and small calcareous shadows in both kidneys. In the presence of such a low functional test it was evident that but one relief measure at a time could be offered this patient, and as he was experiencing excruciating pain in the right lumbar region, radiating down to the groin, it seemed best to make the first intervention upon the obstructed right ureter. Incision permitted the removal of eighteen stones. The clearing out of this ureter permitted drainage of the right kidney and sufficient repair of the damage it had suffered from damming back of the urine, so that operation upon the other side later became possible.

Final Results of Operative Removal.—Both immediate and remote results must be considered when deciding upon the treatment to be accorded any given case of renal calculus. If we are confronted by an acute pyonephrosis, or either ureter is totally obstructed, as in the case just cited, there can be no question of the necessity of immediate surgical intervention. Again, conservative measures may suffice, as in a case reported by Geraghty and his co-workers, where there were five calculi in four distinct portions of the kidney, but all situated in dilated ends of the calyces. Pyelography was followed by a slight renal colic which resulted in the dislodgment of two of the smallest stones into the renal pelvis. This suggested the possibility of dislodging the remaining calculi by producing mild renal colic, which was attained by over-distending the renal pelvis. The three remaining stones were expelled into the pelvis after the second dilatation, whence they were removed through a simple pyelotomy incision.

It is always necessary to consider whether more damage will be done to the kidney by the stones being allowed to remain, or by the trauma incident to taking them out; also, whether the operative risk is not so great as to offset any benefit which might be expected to follow the removal of calculi. The question as to whether it is possible to detect and remove all the stones present must also be carefully weighed. To this end the application of renal fluoroscopy at the operating table is now of great assistance[17] and the more general use of these methods

will no doubt increase the number of satisfactory results obtained after operative procedures for the removal of renal calculi.

Recurrent Stone.—When on examining a patient from whom calculi have been removed, some time after operation we find that more calculi are present, the question immediately arises as to whether these stones have formed since the intervention, or whether they were present when it was carried out, but were not detected by the operator. It has been established by Braasch that following removal of calculi there is recurrence in at least 10 per cent of the cases, and of Barney's 20 patients at the Massachusetts General Hospital, 9, or 45 per cent were found to have calculi within a short period after operation. The probability of permanent cure seems about 2 to 1 according to Cabot and Crabtree.

The chances of recurrence thus become a very important factor when considering the renal calculus question from any angle. As we have already seen, it has a grave import in the decision as to the advisability of making any attempt to take out multiple stones, or those of the large "staghorn" type, especially if the kidney is known to be infected, because under these conditions recurrence, or the overlooking of tiny stones or fragments, is almost inevitable. It would seem as if urologists generally are inclined to be over-optimistic in regard to the final outcome of such cases. While the surgeon is justified in assuring the patient that the operative risk is very small and that the stone is almost sure to eventually destroy the kidney if it is allowed to remain undisturbed, he should nevertheless inform the patient also that recurrence is very frequent, so that permanent cure can by no means be assured.

SOLID TUMORS OF THE KIDNEY.

The kidney may be the location of either benign or malignant growths, but although nearly all forms of neoplasms have at one time or another been found in the renal tissue, statistics inform us that renal tumors constitute but 2 per cent of all neoplasms observed, so that we are justified in stating that tumor of the kidney is a relatively rare disease.

Benign tumors are so infrequent as hardly to merit discussion. Benign adenoma may however, sometimes become malignant, and for this reason its recognition is important. If a non-malignant tumor attains a large size it is likely to produce pressure symptoms and at times hematuria, but these growths are frequently present for years without giving rise to any symptoms whatever. Adenoma, angioma and lipoma are occasionally found in the kidney.

Malignant tumors.—All malignant tumors of the kidney have a very rapid growth, and as the initial symptoms are indefinite, if not altogether absent, the neoplasms do not usually come under observation until all hope of clinical cure is long past. Hematuria frequently

gives the only indication of the presence of carcinoma or sarcoma, and in hypernephroma even this sign may not be in evidence until the condition is well advanced.

Papillary Tumors.—Most of the tumors found in the renal pelvis are of the papillary type. Of the 585 cases of renal tumor collected by Albarran[1] in 1900, 42 of the neoplasms were located in the renal pelvis, and of these, 18 were papillary growths. The most recent compilation of such figures appears to be that of Hryntschak[44] who gathered 68 cases of renal tumors unquestionably originating in the pelvis.

Etiology of Pelvic Tumors.—The theory which puts forward long-standing irritation and inflammation as a cause of the proliferation of malignant cells would seem to be offered considerable confirmation in the production of renal pelvic tumors, as irritative conditions such as the accretion of urinary calculi and the inflammation set up by infective organisms, appear to precede very frequently the appearance of these neoplasms. It is asserted by some authorities, on the other hand, that the presence of calculi has no relation to the origin of papillary tumors in any part of the kidney, and that but few cases of stone with papilloma have been reported, and that even when stone and a neoplasm have been coincident, the stone is apparently the result of the same irritative factor which caused the epithelial proliferation.[77]

Pathology.—Initially a papillary growth may be strictly confined to the renal pelvis, in this location often presenting a number of flat or thickly pedunculated tumors. Extension to the calyces quickly takes place however, and this frequently extends to the orifice of the ureter, causing partial or complete obstruction. As a result of this the pelvis is soon greatly dilated and the kidney itself enlarged; indeed, very shortly the entire organ may be metamorphosed into a hydronephrotic sac. Extension from the pelvis, down the course of the ureter to the bladder is very common, the ureter being occasionally occluded throughout its entire length. In a number of reported cases where the primary lesions were apparently benign, malignant metastases or recurrence followed shortly after operation, and it has been observed that the majority of papillary tumors of the renal pelvis are histologically similar to malignant papillomata occurring elsewhere in the urinary tract.

Symptoms and Diagnosis.—Frequently this type of growth causes no pain whatsoever, but some patients give a history of a "dull ache" constantly present, and the evacuation of clots or fragments of the growth may produce severe attacks of typical renal colic, or the distention of the pelvis by the temporary damming back of the flow of urine induces symptoms such as are associated with hydronephrosis. The clearing of the obstructed ureter will give relief from the pain, and will usually be evidenced by abundant hematuria.

Hematuria is indeed, in this as in other renal neoplasms, practically the only symptom which is constant and reliable. The great vascular-

ity of papillary growths and the ease with which they are traumatized makes them peculiarly subject to hemorrhage, so that hematuria will occur frequently if not constantly. The bladder as seen through the cystoscope, often appears normal, although some evidence of papillomatous growth can usually be observed in or about the ureteral orifice on the side affected. If the bladder has already been invaded, the vesical growths arising from extension of a process originating in the kidney will be low and flat, and will not show the wavy arborescence and villosity which occurs with primary papilloma of the bladder of the same side. Braasch has said that if cystoscopy reveals a papillary tumor of the bladder together with renal unilateral hematuria, the probable diagnosis would be pelvic epithelioma with vesical metastases. When there is no tumor of the bladder the diagnosis becomes more difficult. In the majority of cases the diagnosis can be made quite certain by means of the first pyelography, for if the growth is large enough, it may occlude the pelvis entirely. Usually, however, there is an irregular, partially obliterated outline of the pelvis, together with dilatation or elongation of one or more calyces. It must be remembered that partially organized blood clots in the renal pelvis may cause an outline simulating filling defects.

Papillary Adenocarcinoma.—Papillary adenocarcinoma generally designated as *hypernephroma*, is the most common form of renal tumor. These growths have been classified according to their cell structure into three groups:[38] *a*) Those with clear cells; *b*) those with granular cells, and *c*) malignant cystadenomata. The tumors of each division have a definite and individual histological structure, and a definite corresponding postoperative course. The clear-cell type form circumscribed yellowish tumors, most commonly composed of a mass of small individual nodules, very vascular, and held together by intervening connective tissue. They extend rapidly by continuity, infiltrating the renal parenchyma and the pelvis, and frequently invading the veins as well. Their histological structure is a stroma or meshwork of capillaries surrounded by one or more layers of extremely large clear epithelial cells, with deeply-staining, rounded nuclei. The cells are usually polygonal and flake-like in appearance, not infrequently being finely reticulated.

The granular-cell type of adenocarcinoma is much more malignant than that having clear cells; of smaller size and more homogenous texture, they are more likely to infiltrate and involve the renal pelvis. Often they have no capsule, and on staining, will show considerable variation from the characteristic papillary structure, often tending toward an alveolar form. The third type, malignant cystadenoma, occurs much less frequently than the two previously mentioned. They have a distinct "cord-like" papillary formation, with bands of fine connective tissue, covered with a single layer of flat cuboidal cells which stain very deeply. They are ordinarily single, but multiple growths of large size are observed occasionally. They are encapsulated

and always freely movable, on account of which, as well as because of their relatively low degree of malignancy, they offer a better chance of successful removal than some of the other types.

Renal Tumors of Early Life.—So-called hypernephromata occur quite frequently in infants or children under three years of age,[63] constituting about one-third of all the renal neoplasms coming under

FIG. 216.—External view of an hypernephroma. This kidney was removed in an entirely satisfactory manner under regional anesthesia without reinforcement of any kind. The patient made a rapid and uneventful recovery, but died one and a half years later of metastases.

treatment. Sometimes these tumors attain a very large size, so as to enormously distend the child's abdomen, but until they cause a visible enlargement they are apt to go unobserved, as they produce few early symptoms. In type these growths vary considerably, although they are generally conceded to be essentially embryonal; adenomata and sarcomata predominate, though the mixed-cell tumor is the most common finding.

Fig. 217.—Gross longitudinal section through the hypernephroma shown in the previous picture. It will be noted that there is a necrotic area in the upper pole with abscess formation. Throughout the entire kidney are seen small tumor masses.

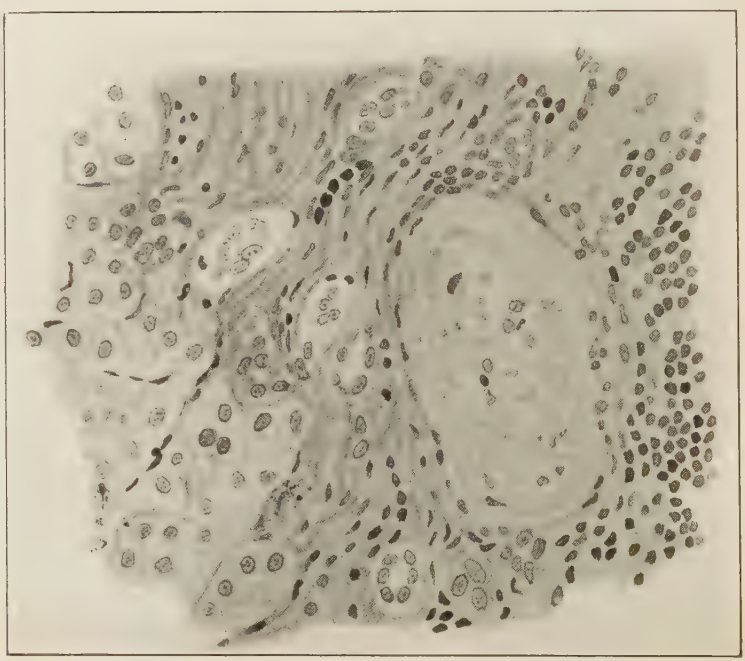


Fig. 218.—Microscopic section of a hypernephroma showing the bizarre arrangement of nests of cells, some of which show nuclei with varying types of mitotic figures. This is an example of the clear-cell type of papillary adenocarcinoma.

The malignant renal growths of young children can frequently be removed with surgical success, but the likelihood of recurrence is so great that the outlook in all cases is exceedingly gloomy. In many cases metastasis begins very early, often before the presence of the original growth is suspected. Children are frequently brought into the clinic with black eyes and a history of a fall or other trauma, to the effects of which all the symptoms are attributed. But by the

FIG. 219.—Pyelogram of hypernephroma. This peculiar distortion of the renal pelvis accompanies the rather large tumor of the upper part of the kidney. The gross specimen is shown in Figs. 216 and 217.

time metastasis to the orbit, the cause of the black eye, has taken place, the little sufferer can hope for no aid from any surgeon, no matter how skilled.

Sarcoma.—Sarcoma of the kidney is undoubtedly a rare condition, and many of the growths in the renal tissue which are so designated are in all probability not true sarcomata. The mixed-cell tumors found in the kidneys of children are often incorrectly called sarcomata.

The actual renal sarcoma is most apt to make its appearance in young adults; its growth is generally rapid, and almost universally fatal. In those cases which have come under observation early enough to make nephrectomy possible, recurrence has usually been rapid, so that even when the diagnosis is reached very promptly the fatal termination is not long delayed. Early metastasis, especially to the liver, is almost universal, and the prognosis in all cases is very grave.

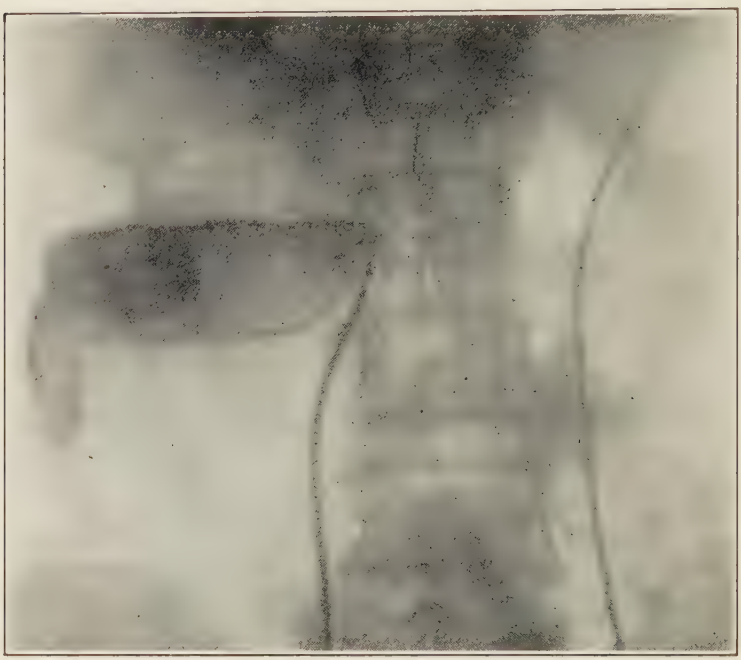


FIG. 220.—Pyelogram of carcinoma of the kidney. The bizarre distortion here shown is only one of a multitude of such irregular pictures seen in this type of kidney lesion. Every pyelogram of kidney tumor is different, for tumefaction is the Bolshevist of pathologic processes and follows no rules. This patient had right upper quadrant pain, a little jaundice and was about to be operated upon for gall-bladder disease. Routine urine examination revealed blood. Pyelography cleared up the diagnosis.

Diagnosis of Renal Tumor. In the diagnosis of renal malignancy three cardinal symptoms have long been recognized—hematuria pain, and a palpable tumor. To these our modern diagnostic measures have now added a fourth, characteristic deformity of the renal pelvis as revealed by pyelography. It is always best to precede the pyelographic examination by ordinary radiography, as the shadows cast by stones are clearer before the pyelographic medium is injected. The deformities which a properly made pyelogram will reveal, for example, displacement or contraction of the pelvis, which may or may not have an accompanying narrowing and elongation of the calyces, are pecu-

liarly characteristic of the presence of renal neoplasm, and offer strong differential evidence against hydronephrosis or tuberculous infection, with which malignancy may often be confused.

Carcinoma.—Carcinoma of the kidney is universally acknowledged to be a very rare disease, and primary carcinoma in that organ is almost unknown, most of the growths being secondary deposits from other organs. As it is only within a few years that any differentiation has been made between renal carcinomata and the other malignant growths mentioned in the preceding paragraphs, comparatively few statistics as to incidence, type or prognosis are available. Waldeyer long ago demonstrated that carcinoma in the kidney arises from proliferation of the renal tubules, and one of the most striking points in its histopathology is the mass grouping of the malignant cells, which show no definite arrangement, but infiltrate the tissues in all directions, often being found growing in among apparently normal cells. At times the tubular arrangement of the normal renal tissue will be mimicked by the columns and cords disposed in regular array which are presented by the malignant cells, but usually, irregular masses will predominate. A primary renal carcinoma seldom reaches any considerable dimensions, as it is of such severely malignant type as to be rapidly fatal before it has time to grow very large. As is the case with other renal malignancies, extension and metastasis are both early and rapid in growth, the lungs and liver being the organs most frequently first affected.

Primary carcinoma of the kidney is more likely to be found on the right side than the left, according to Henry Morris, and it was also his conclusion from an extensive review of literature, that this particular renal neoplasm occurs much more frequently in men than in women. As regards age, it is found like other carcinomata, largely in subjects of the "cancer age," that is, in the fifth, sixth and less frequently, the seventh, decade of life. What has been said of the diagnosis, prognosis and treatment of other renal neoplasms, is true also of carcinoma. Early indications are often lacking, and by the time the surgeon's aid is sought, any hope of cure, or even temporary relief, must in most cases, be abandoned.

CYSTIC DISEASE OF THE KIDNEY.

Solitary cysts are found in the kidney under varying conditions and may be either congenital or acquired. Large solitary cysts producing abdominal tumors are seen but rarely, and their cause, though by no means accurately determined, is probably some undiscovered obstruction in the uriniferous tubules, dilatation being caused by the obstruction to the continually excreted urine. Such cysts are usually unilateral, and can be classed as large retention cysts. Most commonly they are located at one or the other pole of the kidney, and vary greatly in size, for while most of those reported have been about

the size of an orange, some have been known to weigh as much as 16 pounds. The contained fluid is of a clear serous character in most cases, although occasionally it has been found urinous, gelatinous, or even mixed with blood or caseous material.[23]

Polycystic kidney is usually congenital, and in the fetus the organs may be so enlarged as to act as an impediment to labor. The kidneys have been described as represented by a conglomeration of cysts, varying in size from a pea to a marble.[69] The nature and cause of the condition has never been established. Most fetal cases die *in utero* or within a few hours of birth, for other anomalies are usually associated with that of the kidney; yet a considerable number of instances

FIG. 221.—Kirwin's case of calcified solitary cyst of the kidney. Roentgenogram showing the appearance of the cyst before pyelography.

are on record where the condition has been compatible with life so that it has been seen in adults even as late as the fifty-fifth year. Operative interference has ended disastrously in the majority of cases, and no surgical relief should be contemplated except in the presence of infection.[19]

Where no cause can be found for obstruction and retention of urine in the tubules; in particular where the characteristic structure of the mesonephros is still in evidence, congenital cystic kidney may be most reasonably ascribed to the persistence of misplaced mesonephrotic elements. But there is still some room to doubt the justification of assigning a congenital cause to all cystic kidneys, when we recall that

it is possible for cysts to develop as the result of compression of the tubules and papillæ by the growth of a neoplasm or other causes, which may possibly arise at any period of life.

Adult Cases.—Those cases of cystic kidney observed in adult life are likely to prove fatal between the ages of forty and fifty years, but where autopsy has been done the findings have usually shown that the process has been going on for a considerable period. Ordinarily both kidneys are affected, although the process is likely to be more advanced

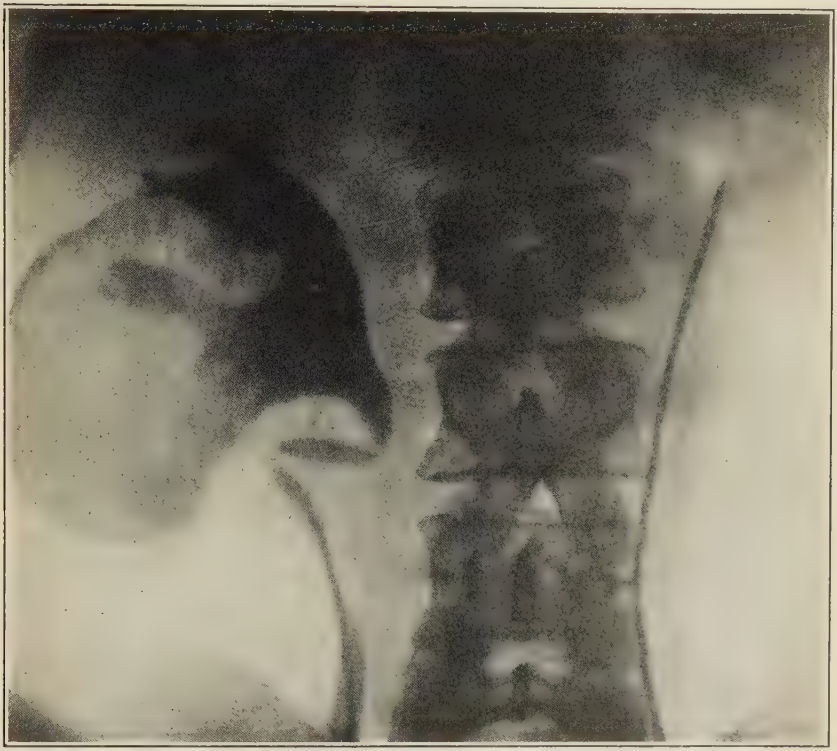


Fig. 222.—Kirwin's case of calcified solitary cyst of the kidney. Pyelo-ureterogram shows the pelvis of the kidney surrounding the cyst in very much the same manner in which the setting of a ring grasps the jewel it contains. There is a kink at the ureteropelvic junction and another about 3 cm. below this point.

on one side than on the other. The organ will have the appearance of being changed into a mass of cysts, the sizes of which run all the way from a pea to a cherry, with transparent walls through which the contained yellow fluid will be plainly visible. The characteristic kidney outline will usually be discernible, although in the congenital cystic kidneys sometimes seen during labor, the affected organ may be so large as to practically fill the abdomen. In adult life the kidney does not often attain such a size as to be detected during life by inspec-

tion, although a few cases have been recorded where it formed an easily recognizable mass, visible as well as palpable.

Acquired renal cysts are usually small, multiple and occur most commonly in kidneys which have undergone structural changes whereby the tubules have been obstructed, and, because of there being no outlet for the urinary secretion, retention cysts have resulted. Among the renal conditions with which such cysts are likely to be associated are chronic interstitial nephritis, cicatrices from infarcts, deposits of urinary salts in the kidneys, and inflammatory conditions of the renal pelvis which have extended to the pyramids and obstructed or obliterated the tubules.

FIG. 223.—Kirwin's case of calcified solitary cyst of the kidney. The walls of the cyst are seen to stand out from the kidney substance in a very striking manner. The plaque-like arrangement of the walls is very clearly observed inside of the cyst.

Symptoms.—The symptoms produced by large solitary or by multiple cysts are never very sharply defined, and unless coexisting disease, calculi or neoplasms produce changes in the urine, and marked alteration in the renal function, the output of urine will remain normal to every test and offer no indication of the actual state of affairs. If the cysts attains great size there may be certain pressure symptoms and in such cases also there is likely to be a visible tumor in the lumbar region, with a sense of intra-abdominal weight, such as the patient experiences in the presence of tumor of any kind in that region. When these manifestations are in evidence, a diagnosis of hydronephrosis,

gall-bladder disease, or ovarian tumor is likely to be made. Hydronephrosis may be eliminated by complete examination of the urinary tract by cystoscopy, ureteral catheterization, tests of the renal function, and pyelography. All of these measures should be carried out before resorting to nephrectomy. Often the cystic kidney may still possess

FIG. 224.—External view of unilateral polycystic kidney found at autopsy. This is a very rare condition, as polycystic disease is almost always bilateral.

a fair share of functionating tissue, and not only is it unwise to deprive a patient of this when there is any chance of preserving it, but also if the function has continued on the affected side, the opposite kidney if deprived suddenly of its mate, may not become adjusted to assuming the work of both organs, and may be unable to carry on renal function efficiently enough to be compatible with life.[69]

Diagnosis. The diagnosis during life is on the whole decidedly difficult to make. Symptoms of uremic coma are often the first indications of the existence of the condition in adults, and at the period when the presence of the cysts has no effect upon the excretion of urine, it is of course, quite impossible to make a diagnosis. Only when (*a*) one or both kidneys are sufficiently enlarged to be palpated, or (*b*)

FIG. 225.—Pyelogram of the polycystic kidney. The major and minor calyces are dilated and distorted. The pelvis is much enlarged and shows many filling defects due to compression and encroachment by the cysts. This is quite a characteristic picture and by observing its outstanding features when pyelography has been done one will rarely have difficulty in recognizing the condition.

when the cysts encroach upon and rupture into the renal pelvis, or finally (*c*) when the parenchyma is sufficiently encroached upon to interfere with the normal excretory function of the kidney, will clinical pictures present themselves which serve to make the careful observer suspect the possibility of this unusual condition being present.

The indications most likely to lead to a correct diagnosis are tumor,

when present, hematuria, and those symptoms of renal insufficiency which are frequently the first manifestations to come under the notice of the medical practitioner. At times careful palpation will suggest the true nature of the tumor, and inflation of the colon, or the employment of pyelography may help to locate the mass in the renal area. It has been observed that some of the major calyces may appear flattened, or even wholly obliterated; that they may be broadened or retracted, or that the renal pelvis may be displaced from its normal position and appear lengthened or rounded.

When hematuria is present it may be a difficult matter to establish its connection with a cystic condition of the kidney. A new-growth in the parenchyma, or the pelvis will produce exactly the same symptoms, and the pyelographic appearance in both conditions is practically identical. The passage of blood clots through the ureter may induce colicky pains similar to those caused by the excretion of stones, but this too, not infrequently occurs when a solid tumor is present, so that it cannot be regarded as a diagnostic point of value except in conjunction with other more positive indications.

But if the cystoscopic view shows that the hemorrhage is above the bladder and palpation tells that there is a nodulated enlargement of the kidney, while we have in addition, well-marked indications of renal insufficiency, the diagnosis may usually be reached without a great deal of confusion. Yet both hematuria and palpable enlargement are so often wanting that these renal symptoms cannot be differentiated from those due to a chronic interstitial nephritis. It is evident therefore, that the condition is one very difficult to establish with certainty, even when all the most modern methods are employed with the greatest diagnostic skill. It is to be hoped that more extended study upon this interesting and curious condition may increase our knowledge of its etiology and make possible its more intelligent and successful treatment.

Hydatid Disease.—In connection with cysts of the kidney hydatid disease should be mentioned, although this affection is rare in this country, those cases which do occur being practically always found in immigrants who have imported the parasites from Europe. Renal echinococcus cysts as a rule, are single and encapsulated in a tough membrane which grows thicker as the cyst enlarges, until its walls often attain a thickness of $\frac{1}{2}$ inch. The pelvis appears to be the most common location of hydatid cyst, and adhesions often connect it with neighboring organs into which rupture may occur, making the diagnosis that much the more difficult. Even rupture into a bronchus has been reported, but this can take place only when the cyst has attained a very large size. If the urine contains hooklets or small daughter-cysts there will be no trouble in deciding upon the nature of the tumor, but otherwise, as frequently the kidney tissue is little if at all altered, even radiography can give little aid. Typical hydatid fremitus can seldom be elicited. If the diagnosis can be established,

the sac should be evacuated through a lumbar incision, and proper drainage provided. It is never necessary to perform nephrectomy. The authors have recently had a case of renal echinococcus disease at the New York Hospital. The patient had a large collection of cysts in the left kidney, some of which were passed into the bladder and recovered in the urine, making diagnosis very easy.

MOVABLE KIDNEY.

At no time is the normal kidney a fixed organ, as it constantly moves up and down with the impetus of respiration, even though this movement is too slight to be perceptible on palpation. Abnormal mobility of the kidney, however, frequently occurs, and clinically may be divided into three stages: (1) A *palpable kidney* is one the lower half or more of which can be definitely felt on deep inspiration; (2) a *movable kidney* is one upon which the examining hand can define the upper end of the organ, and can restrain it from returning to its former position during expiration; (3) a *floating kidney* is one that can be moved freely about the abdomen in all directions, even in some cases, across the median line.[66]

Age and Sex Incidence.—The greatest number of cases of abnormal kidney mobility are found in women between the ages of twenty and forty years. Men are seldom subject to this particular condition, probably because the fossa in which the kidney lies, is, in women, wider and shallower at its lower part than is the case with men. Repeated pregnancies which serve to relax the abdominal wall are not infrequently followed by movable kidney, and slender, poorly-nourished women who have never borne children but are lacking in perinephritic fat, are also frequent sufferers.

Many mobile kidneys are discovered only by accident when an examination is being made for some other purpose, no symptoms having ever been noticed previously, but more often there will be pain, digestive disturbance and changes in the urine, with general derangement of the functions of the urinary tract. There may also be pressure symptoms manifested by neighboring organs, and nervous manifestations such as neurasthenia and hysteria.

Symptoms.—*Pain* caused by a mobile kidney may vary all the way from being experienced only on palpation of a movable lump in the abdomen, to the severe form known as *Dietl's crisis*, which occurs suddenly, with violent abdominal pain, nausea, vomiting and collapse, sometimes accompanied by chills and high temperature. Physical examination will usually show the kidney palpably enlarged and quite tender to the touch. If the condition is due only to kinking of the ureter, when this is relieved there will be a transient polyuria and the symptoms will subside, but if the crisis is caused by torsion of all the structures of the pedicle which brings about an intense venous congestion in the kidney, with greatly increased intracapsular

tension, the attack will not subside so quickly. Temporary hematuria may follow such a seizure, and frequent and painful urination is quite common. Repeated attacks may eventuate in chronic hydronephrosis, due to dilatation of the renal pelvis.

The *nervous symptoms* are often the most serious aspect of the condition, and the fixation operation may not in any wise relieve them. Again, the correction of the renal abnormality will cause a complete disappearance of all neurasthenic manifestations. In any event, the hope of relieving the neurological disturbance is a strong indication for operation.

Treatment.—*Operation*, speaking in general, is indicated: (1) When the kidney is so extremely mobile that an external support, truss, binder, etc., fails to fix it; (2) when tenderness to pressure is so great that no mechanical means of fixation can be worn; (3) when Dietl's crises constantly occur; (4) when continued discomfort persists in the loin, combined with digestive disturbances, vomiting and marked nervous symptoms; (5) when continued motility has produced hydronephrosis or pyonephrosis; (6) under any circumstances which have fixed the kidney in an abnormal position, inflammatory adhesions for example, thus producing symptoms of obstruction which continually recur.

THE "SILENT" KIDNEY.

No consideration of kidney conditions would be in any degree complete if no reference were made to what, for want of a more exact designation, has been termed the "silent" kidney. No other organ of the body is capable of undergoing such extensive pathological changes without producing symptoms of any kind, or at most manifestations which are so trivial as to be overlooked by patient and physician alike. Often extensive and long-standing disease will come to light only by accident, nothing having occurred to direct any attention to the renal region.

Reno-Renal Reflex.—Again the patient may complain of pain or tenderness in the region of one kidney, the closest investigation of which will not reveal anything abnormal, whereas examination of the opposite organ, concerning which no complaint has ever been made, may show the existence of an advanced disease process such as tuberculosis or nephrolithiasis. Very often some other organ may be unjustly accused of producing symptoms for which the kidney alone is actually responsible, and the appendix or other suspected organ, may be subjected to operation in a vain attempt to afford relief of the patient's distress.

Renal Tuberculosis.—Renal tuberculosis frequently advances far without giving any indication of its location. If the process does not occlude the ureter, the flow of urine from the tuberculous focus will continue unabated, and the only symptoms produced will be irritation of the bladder which receives the infected urine from that side.

So frequently does this happen, especially in young adults, that it is always wise to look upon every case of bladder irritability for which we do not find a ready explanation, as a probable renal tuberculosis.[14] The crippled condition of the affected kidney is likely to cause hypertrophy on the opposite side, so that renal examination will reveal enlargement in the region which is actually healthy, thus directing suspicion there instead of to the side where the trouble really lies.

Calculus.—Calculus may be present in the kidney for long periods without producing symptoms of any kind or, as we have already seen, may cause pain which is referred to the other kidney, or to some wholly distinct organ. When there are stones in both kidneys there may be pain on one side only, which emphasizes the necessity of inspecting both sides before any intervention is undertaken. Both ureters should be catheterized at the same sitting and radiographic examination undertaken if conditions in any way indicate its necessity. Large numbers of stones of different sizes may be present in a kidney which gives its possessor no pain whatever, or perhaps only transient attacks of no great severity, though at the same time complete destruction of the kidney, with its transformation into a thin-walled sac of pus may be steadily progressing.[7]

Neoplastic Growths.—The fact that renal neoplasms seldom cause pain until they are too far advanced to be successfully extirpated, is a fact known to every surgeon. The malignant hypernephromata to which little children are subject, often give no indication of their presence until metastasis has taken place, the child having never manifested discomfort of any kind. When pain does occur in connection with the growth of renal tumors it is due to the passage of blood clots or pieces of the neoplasm, which are able to produce colic similar to that caused by stones.

Renal Anomalies.—In our consideration of anomalies it was pointed out how frequently these malformations may exist without giving the slightest indication of their presence, notwithstanding the fact that it is established that abnormal organs are much more subject to disease or even to trauma than those which conform to the normal pattern.[48] The same is true of movable kidney. Operation on other organs not infrequently shows marked mobility in a kidney concerning which there has never been any complaint,[66] and as has already been pointed out, conditions which have their origin in this kidney mobility, especially the neurasthenic disturbances, are all too frequently attributed to some other cause and permitted to continue indefinitely, when proper attention to the renal condition would quickly abolish them.

Hematuria.—Hematuria may give evidence of kidney pathology when pain or other localizing symptoms are entirely absent. Therefore, this manifestation should never be neglected, and no patient should be dismissed with the diagnosis of "idiopathic" or "essential" hematuria until every diagnostic means has been fruitlessly employed in the endeavor to establish its source. If this were systematically done

the terms *idiopathic* and *essential* would be less frequently seen in the nomenclature of urology. The possibility of some extensive lesion in a "silent" kidney should always be present in the mind of the urologist, and he should never rest content until he has established beyond any doubt whether or not there are abnormal conditions in existence, despite the absence of pain, or of other ordinarily accepted indications of renal disease.

SURGERY OF THE KIDNEY.

Anesthesia.—In the authors' practice renal surgery is now carried out in most instances under regional anesthesia, and we shall make no attempt to discuss the older methods which are too well known to require any description in a text-book of this character. We do not, however, advocate that regional anesthesia be employed in every case of surgery of the kidneys, for every surgeon is called upon to care for patients whose temperamental make-up is such as to make it impossible to carry out even the most trivial intervention while they are conscious of what is going on. Unless the coöperation of the patient can be obtained regional anesthesia is quite out of the question. Usually, however, the attainment of this coöperation is not difficult. The procedure should be briefly explained and the advantages of a painless operation without the employment of a general anesthetic tactfully pointed out, emphasizing particularly the lessened dangers of the regional method, and the abolition of postoperative discomfort. The patient should be told that he will feel a few needle pricks when the first injections are made, and that later there may be a few pulling sensations, but that these will be easily relieved as soon as he calls attention to them. Every effort should be made to gain his confidence, to have him feel that the anesthetist has a personal interest in carrying him through the operation without pain or mental anxiety, and that his comfort and ease of mind are at all times the consideration of paramount importance. Parenthetically it may be remarked that not only must he who would attain success in the administration of regional anesthesia be skilled in his work, he must likewise be a keen psychologist, and be prepared to emulate the apostle Paul in being " all things to all men."

Special Indications.—Regional anesthesia is especially indicated in patients who are suffering from an active tubercular process in the lungs, to whom inhalation anesthesia is often very dangerous. If the heart has been demonstrated to have any lesion such as endocarditis or myocarditis, regional anesthesia will have marked advantages over the older methods when renal surgery must be undertaken upon such a patient. Marked arteriosclerosis is another indication for the avoidance of inhalation anesthesia, and finally, if one kidney has been removed, or is known to be functionless, any intervention upon its fellow should not be done under ether anesthesia, as this is well known to be very irritating to renal tissue.

Preoperative Preparation.—In most renal conditions, especially perinephritic abscess and unilateral tuberculosis, operation should be performed as soon as may be after a definite diagnosis is reached, but if possible the patient should receive careful preparation before the anesthetic is administered. From twenty-four to forty-eight hours before the time set for the operation large doses of sodium bicarbonate should be given, by mouth if the patient can tolerate it, otherwise by rectum by a Murphy drip, using a 5 per cent solution. An ounce and a half of castor oil should be given at noon on the day preceding the operation, so that it will act before bed-time, and allow the patient to rest undisturbed during the night. Fluids should be given freely up to the time of operation.

Preoperative Narcosis.—In the Illyes clinic in Budapest, where the most extensive work in regional anesthesia as applied to urology has been done by Snitzer, morphine and atropine are seldom used in preparing a patient for operation under regional anesthesia. We have found, however, that the measures which are satisfactory in dealing with the ordinary clinic patient in Central Europe, cannot be employed so satisfactorily in this country, especially in private practice. We therefore, prefer to administer morphine after the method of Gwathmey: Two hours before operation, morphine, magnesium sulphate and procaine are given; this is followed in an hour by another dose. If the patient is well under the influence of the drugs, no further medication is used, if not, a third dose is administered as the patient goes to the operating room.

The patient should be wheeled to the operating room, lying comfortably on his back, and when he reaches there all unnecessary display of instruments, all evidences of haste or confusion, or an atmosphere of portentous gravity should be carefully avoided.

Technic of Administration.—For the administration of the anesthetic the patient should be seated on the side of the operating table, his body bent slightly forward, the shoulders rolled a little anteriorly and the head somewhat bowed. The feet rest upon chairs so placed that the thighs form a right angle with the abdomen. An attendant stands in front of the patient to support him both physically and spiritually.

In paravertebral anesthesia as applied to renal operations, nerve-blocking need be used on but one side, as our procedures are usually unilateral. Success depends upon blocking the eighth, ninth, tenth, eleventh and twelfth dorsal nerves, as they all send off branches which in one way or another reach the lateral, anterior and posterior parts of the abdominal parietes, supplying one or all of its cutaneous and muscular planes. With the lumbar plexus we are chiefly concerned with the first lumbar and its two main branches, the ilio-hypogastric and the ilio-inguinal nerves. A few branches from some of the other lumbar nerves may appear but they are unimportant, and in any event will be well anesthetized by the regional block in that area.

With the patient in position the points for needle puncture are

located and painted with iodine or some other fairly indelible antiseptic substance. For the intercostal injections the first point is in the eighth space, usually opposite the angle of the scapula, thence downward in each successive space to the location of the twelfth nerve below the last costal border, the punctures being from 3.5 to 4 cm. from the mid-line of the back, about two finger's breadths from the spinous process. As the spinous process may be irregular it must be accurately identified in every case.

FIG. 226.—Injection of 1 per cent procaine into the dorsal foramina, through which the posterior roots of the eighth, ninth, tenth, eleventh and twelfth subcostal nerves pass. This is the first step in the induction of paravertebral anesthesia for operations upon the kidney.

For the lower abdominal or quadratus block two points are marked out, one about 3 cm. from the spine of the first lumbar vertebra extending anteriorly, and the other at a point opposite the anterior end of the twelfth rib, above the anterior-superior spine of the ilium. The lower landmarks are the anterior and superior spines of the ilium. Over each of these points a medium-sized Luer type syringe and needle, carrying a 1 per cent procaine solution, is employed to make a wheal,

and the injections are started by first inserting the needle in the wheals in the intercostal spaces at right angles to the surface of the rib, carrying the injection down to its lower border. When the lower edge of the rib is reached the needle is slightly withdrawn and inclined at an angle of 40 to 45 degrees in the direction of the vertebral column, and is then forced over close along the lower anterior edge of the rib until it impinges on the body of the vertebra, where it is close to the inter-

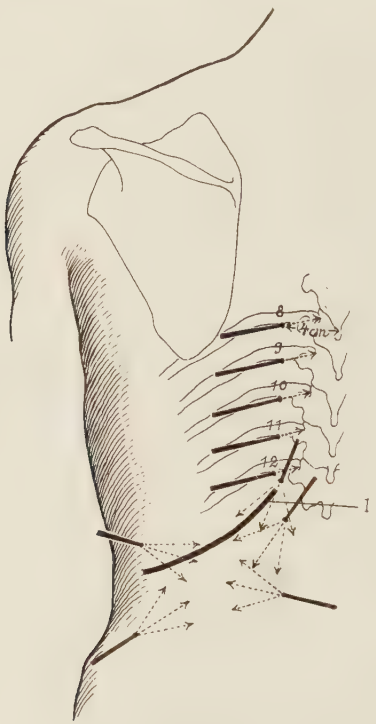


Fig. 227.—This diagram indicates the points of injection of 1 per cent procaine for the induction of regional anesthesia in kidney operations. The curved black line shows the line of incision. It will be noticed that in this method of injection the needle strikes the rib about 2 cm. from the transverse process; it is then manipulated in such a manner that it is introduced below the costal margin and is pushed into the foramen. This method is unsatisfactory in fat or heavily-muscled patients as it is often necessary to insert the needle through as much as 5 or 6 inches of fat and muscle. It has been superseded by the method of Lowsley and Pugh.

vertebral foramen, between the rib and transverse process. Five cc. of procaine are used in each dorsal nerve block, from the eighth to the eleventh; the twelfth nerve being below the rib and its branches ramifying somewhat more, about 7 cc. should be used in this block. At this point it is well to bear in mind that while the nerve is covered by muscle tissue, only the internal intercostal fascia separates it from the pleura; also that the pleura lies nearer on the left side.

The authors have of late used a method of injection proposed by Lowsley and Pugh. Instead of injecting the foramina by finding the angle of the rib and then inserting the needle along its lower border to the foramen under the transverse process, the needle is inserted opposite the spine of the vertebra above, impinging on the bone at the angle formed by the transverse process of the vertebra and the lamella. By pushing it over the lip of bone the needle point will be inserted directly into the orifice of the foramen which conducts the posterior root.

FIG. 228.—Method of Lowsley and Pugh. The arrow in the figure to the right points to the first needle insertion, which is the only one felt by the patient. The skin surface is injected continuously upward about 2 cm. from a line connecting the spines of the vertebræ. From this same point the procaine solution is inserted superficially and deeply into the tissues of the loin, as shown in the shaded areas in the picture. A particularly large amount of the drug is injected into the costo-vertebral angle because of the fact that the twelfth subcostal, ilio-inguinal and ilio-hypogastric nerves emerge at this point, and they are the ones which chiefly have to do with innervation of this part of the body wall. The middle diagram shows the location of the foramina, through which the posterior roots emerge. It will be noted that the foramina in this part of the back are almost opposite the spines of the vertebræ above. The diagram to the left shows the application of the needle opposite the spine. It comes in contact with the bony lamella covering the cord. It is moved slightly lateralward and when passed inward, is at the angle formed by the transverse process with the lamella exactly over the foramen. This is a much surer method of injecting the region of the posterior roots in every case, as there is never any considerable amount of fat or muscle in this area, such as is found a few centimeters farther out.

In the quadratus block the nerves can be effectually anesthetized by injecting in all directions, especially toward the center, at the four points previously marked out in this area. By injecting both superficially and into the deep planes, all the nerves of the abdominal wall, both deep and superficial, will be made insensitive to any possible incision in their vicinity. Before making any incision all the areas should be tested to see if they are perfectly anesthetized, and reinjected

if it is found necessary. About 80 cc., at the maximum no more than 150 cc., of a 1 per cent solution of procaine should suffice to render the patient ready for operation within a few minutes after the injection is commenced. His head should be screened from view of the field of operation, and his attention diverted as much as possible by an attendant especially trained for this duty. The incision should be made gently and carefully and all tearing or roughness avoided. If there is traction on the renal pedicle which causes pain of the nauseating type, it is well to inject a little procaine around it when this structure is

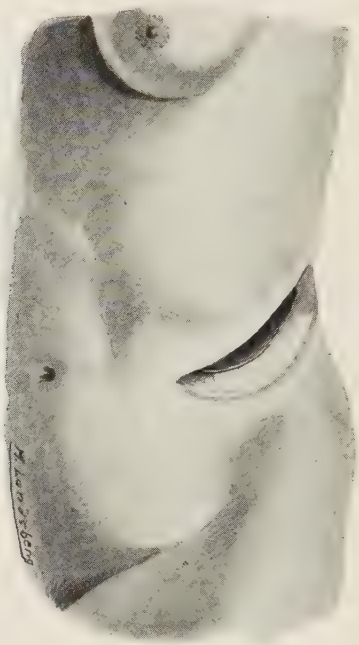


FIG. 229.—The incisions used in operations under regional anesthesia must be larger than those ordinarily used when the patient is under general anesthesia. This is necessary in order to avoid heavy retraction, which is always painful. The customary incision extends from the costo-vertebral angle to a point mesial to the anterior superior spine, about an inch and a half above it.

reached. A few whiffs of ether may be useful here if the patient is unusually nervous. In the majority of cases this will not be necessary, and the patient should leave the table comfortable and without any evidence of shock. There is no postoperative nausea, and the effects of the anesthetic usually persist in some degree for seven or eight hours, thus giving the patient time to regain his normal blood-pressure while still more or less insensitive to pain.

Incisions Employed in Renal Surgery.—There are two ways in which the kidney may be reached, and in some cases it is necessary to approach it from two directions, a procedure which may be said

to constitute a third method. The most natural way is that of the lumbar incision, which leaves the peritoneum intact; the second is abdominal laparotomy which is, of course, transperitoneal. The lumbar route is the one better suited for such conditions as mobile kidney, or any exploratory operation when it seems likely that the kidney may be infected; also for the removal of calculi in most cases. If large tumors are to be extirpated, however, the abdominal route is the one generally to be preferred, and this is likely also to be the more satisfactory in any procedure where it is necessary to inspect both

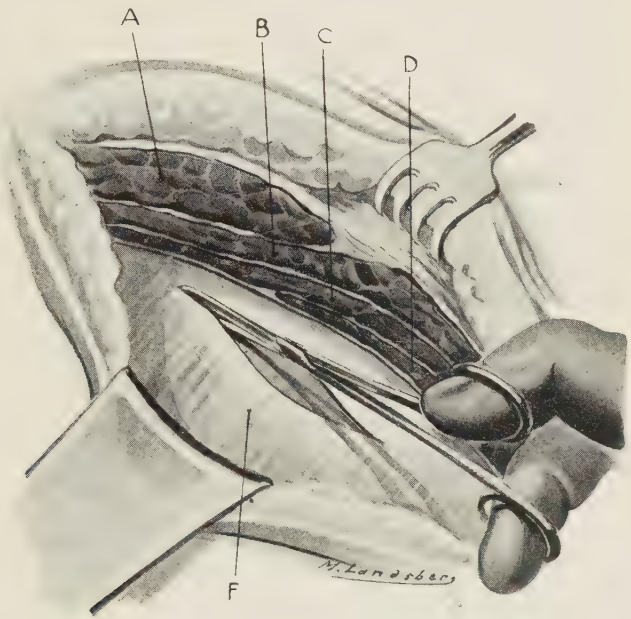


FIG. 230.—The abdominal layers incised in the approach to the kidney are *A*, latissimus dorsi; *B*, obliquus externus; *C*, obliquus internus; *D*, transversus; *F*, fascia. It is found that relaxation of the muscles of the body wall is better under regional anesthesia than when a general anesthetic is being administered. This is probably due to the labored breathing when the latter type of narcosis is used.

kidneys. It has lately been proposed, in the case of large tumors, to do the operation in two stages. First, to open the peritoneum and tie off and incise the renal artery and vein; then to make a lumbar incision through which the kidney and tumor are removed extraperitoneally.

Lumbar Incision.—Lumbar incision should be made parallel to and about $\frac{1}{2}$ to $\frac{3}{4}$ inch from the last rib. It should extend forward from the outer edge of the erector spinæ muscle for 4 or 5 inches. Should a larger opening be necessary, the incision can be extended forward toward the abdomen, thus enabling the operator to open the peritoneum, if this is unavoidable, or it may be curved downward on a line

with Poupart's ligament and the iliac crest. Such an incision should be ample for the delivery of a kidney of any dimensions unless enormously enlarged; or to reach any part of the renal tissue to which attention must be given.

Mistakes to be guarded against in making this incision are wounding of the peritoneum and cutting into the pleura. Should any damage be done to the peritoneum it can quickly be repaired by suture, and the normal position of the last rib usually acts as an efficient shield for the pleura, accidental incision probably only taking place when this rib is congenitally short, or is misplaced.

Abdominal Incision.—Abdominal incision is made either through the middle line or through the outer border of the rectus, on whichever side the affected kidney is located. When the peritoneum has been opened on the left side, the kidney can usually be made out to the inner side of the descending colon, but on the right it will be more difficult to feel the kidney, as it is concealed behind the cecum and colon. But unless adhesions are present, a hand passed beneath the liver at the outer side of the gall-bladder will usually encounter it.

Still another method of exposing the kidney is by a long vertical incision to the outer side of the rectus, avoiding the peritoneum when it is encountered, except in the presence of large tumors, when the peritoneum must be incised to afford sufficient room for their removal. The only advantage offered by this means of approach is the greater amount of space which it puts at the operator's disposal.

Nephrectomy.—Excision or removal of the kidney is most commonly accomplished although a lumbar incision, although the nature of the condition which necessitates the organ's removal will naturally influence the method of approach. If the kidney is much enlarged it may be removed intact by enlarging the usual posterior lateral incision and retracting the peritoneum toward the middle line, which makes the organ more accessible. Cutting the costo-vertebral ligament and quadratus lumborum muscle when necessary, will also permit a more extensive operative exposure.[78]

After the kidney has been exposed it must be separated from its surroundings, and the ease with which this is accomplished will depend upon the presence and number of adhesions, as well as the nature of the disease affecting it. In tuberculosis, pyonephrosis or cystic disease the fatty capsule should be peeled off, and it has been found that splitting the fibrous capsule followed by decapsulation will often aid greatly in the enucleation. Adhesions should be divided with the scissors, and every care taken to avoid hemorrhage before the vessels can be exposed and ligated. The kidney is freed on all sides until the pedicle is reached the pelvis and its ureter then being separated from the bloodvessels and the ureter divided between two ligatures as far down as it can be reached. Sometimes the kidney and upper ureter are freed through the lumbar incision, the pedicle ligated and divided, and the kidney left hanging from the wound with the ureter still

attached, while the patient is turned over so that the renal region may be approached through an anterior rectus incision. This permits the freeing of the lower part of the ureter, which is then ligated and severed at its point of junction with the bladder. The kidney can then be drawn back and the ureter removed through the posterior incision.

If the ureter is not to be removed, a long ligature should be left upon it, and the individual vessels of the pedicle tied separately, after which the kidney can be freed entirely and delivered. The pedicle should always be carefully examined, and if found short and adherent, which occurs frequently in calculus pyonephrosis, or long-standing tuberculosis, it is best to place curved clamps above and below before the final excision of the kidney, the last cut being made between the clamps. It is the custom of the authors to ligate the pedicle before excising the kidney. A double catgut ligature is used, and at the moment of ligation the clamp is loosened, allowing the ribbon-like mass into which it had been compressed to become tubular as the ligature is tightened. A third ligature is transfixed and placed after the kidney has been excised.

Drainage.—In nephrectomy for tuberculosis many operators, following the technic of W. J. Mayo,[65] close the wound without drainage. The patient is placed on the table upon his sound side, with a considerable degree of elevation of the loin. A vertical cut is made from the twelfth rib at its posterior attachment, and a long transverse incision mobilizes the lower wall of the thorax. If the wound is soiled with tuberculous material after the kidney has been lifted from its bed, the cavity should be cleansed as well as possible, filled with normal saline solution and closed. The ureter is injected with 95 per cent carbolic acid, some 10 to 20 minims being usually employed.

Hemorrhage is perhaps the most dreaded sequel of nephrectomy. It is most likely to take place after the pedicle has been severed and the clamp released. Sometimes the operator fails to include all the vessels in the ligature, or places a second ligature over the first so that the original one ceases to be effectual, and then severs this ligature when the kidney is taken out. Slight oozing can usually be controlled by hot pads, but if the flow of blood is profuse it may obscure the field so completely as to make any procedure very difficult. Any hemorrhage should be wiped up at once with hot pads and the origin of the bleeding located if possible. If it can be found the cut vessel should be caught with a hemostat and ligated. When this cannot be done, even if the vessels from which the blood is escaping are not identified, digital pressure upon the pedicle will often serve to check it. This procedure often gives a chance for the removal of clots, so that examination is possible and the clamp may be placed more advantageously.[73] The operator should remember the possibility of injuring the intestine by injudicious application of clamps under these circumstances. If the hemorrhage comes from an anomalous vessel it may be quite severe, but will never be as profuse as that having its origin in the

pedicle, or from the vena cava, if this has received an accidental injury during the nephrectomy. The repair of such an accident requires rapidity and skill, as it is likely to be attended by grave consequences. Clarke remarks somewhat doubtfully that ligature of this vessel "is said to have been attended by success."[19]

The healing of tuberculous sinuses sometimes seen after nephrectomy, is found to be remarkably stimulated by the judicious use of the alpine light. In the series of cases now under treatment by the authors at the James Buchanan Brady Foundation for Urology of the New York Hospital, very rapid cure of long-standing disease has repeatedly been brought about by this simple but effective form of therapy.

Nephrotomy. -Simple incision of the kidney may be either merely exploratory in character, or for the purpose of establishing drainage, removing stones and so on. It is usually undertaken by the lumbar approach and the operator's chief problem is in deciding which is the best point for making the incision. For exploratory purposes it will be found more advantageous to enter the kidney at the point where the pelvis and parenchyma meet, whence the parenchyma may be incised in any direction which may seem desirable, and easily closed again by sutures without risk of subsequent urinary leakage. An incision of this kind will also serve if decapsulation is to be carried out, for the renal capsule can be readily stripped off as far as desired. When the operation is being done for the removal of calculus, the incision had best be made in the convex border, slightly toward the posterior portion of the convexity, so as to avoid the vessels as much as possible. If the stone does not come into view as soon as the kidney is opened, it will have to be searched for with the finger, and after it is secured it should be carefully examined, to be sure that it is intact, and that portions of it, or other stones are not being left behind. Special fluoroscopy may be advantageously brought into play in this operation, as the roentgen-rays are of material assistance in detecting stones which might otherwise be overlooked.

Infected hydronephrosis is sometimes treated by nephrotomy, although in the majority of such cases nephrectomy will later be found necessary. When the establishment of drainage is the object of the nephrotomy the incision must be through the outer wall and the lowest part of the kidney. In most cases, long-continued retention will have rendered the organ sufficiently distended so that it will offer no difficulties to finding a way into the interior. A large drainage tube should be used, and if much pus is present and distention marked, the cut surfaces of the operated organ should be sutured to the fascial margin of the lumbar wound, thus forming a fistula which will usually close spontaneously after the lapse of a reasonable time.

Complications are very likely to follow this operation. At times the fistula will fail to close, urine continuing to discharge from it after the lapse of many weeks. An in-dwelling catheter allowed to remain in the ureter will usually serve to deliver the urine so that the fistula

will heal, but if this expedient fails, a secondary exploration will have to be undertaken. If pus flows from the wound the same procedure will be in order.

Hemorrhage after nephrotomy, as after excision of the kidney, is likely to occur, and must be guarded against by every expedient at the surgeon's command. If it continues in spite of all attempts to control it, a secondary nephrectomy will be the only resort. The pedicle should be grasped and the field cleared and inspected. If but one or two vessels are implicated these can usually be seized with forceps and ligated, and generally oozing can be controlled by pressure with hot sponges as after nephrectomy. The likelihood of such a complication arising however, once again emphasizes the importance of knowing exactly the condition of the opposite kidney before any intervention is started on either side. The knowledge of the functional capacity of the unoperated kidney will enable the surgeon to judge whether he can safely remove one in which hemorrhage is uncontrollable, and in many cases failure to have ascertained this before operation may mean the needless sacrifice of the patient's life. However, hemorrhage after nephrotomy is easily controlled as a rule, by including a small strip of fat in the repair of the wound in the kidney parenchyma.

Pyelotomy.—It has been estimated that fully 80 per cent of renal stones are either in the kidney pelvis or the calyces, and even if located in the cortex, small stones may be more easily reached through the pelvis and a small incision in the parenchyma. For this reason pyelotomy has of late become a popular operation, as offering a greater margin of safety and less danger of hemorrhage and extensive trauma. Some experienced operators even go so far as to say that if a stone is too large to be removed through the pelvis, or without destruction of a large amount of renal tissue, the idea of saving the kidney should be abandoned. If the opposite kidney is normal, the small amount of functionating renal tissue which would remain after extreme parenchymal exposure is not of sufficient value to risk postoperative infection and hemorrhage.[49]

Indications.—Generally speaking, if the stone lies wholly within the pelvis, or in the upper part of the ureter, or in the lower calyces of a kidney the pelvis of which is dilated, pyelotomy will be the operation of choice. But if the kidney proves to be bound down by strong adhesions so that it is difficult if not impossible to deliver it through the incision, or if the fatty capsule of the renal pelvis is friable and infiltrated with inflammatory exudate, it should not be attempted. A short pedicle makes this procedure more difficult but not necessarily impossible, if a good exposure of the kidney can still be had. If the patient is very fat, all the difficulties are increased, but some operators have attained sufficient skill so that they can locate and remove stones without delivering the kidney into the wound.[71]

Location of Stones.—The surgeon about to perform a pyelotomy will usually be confronted by one of three situations. 1. The stone may be firmly impacted at the point where the pelvis opens into the ureter,

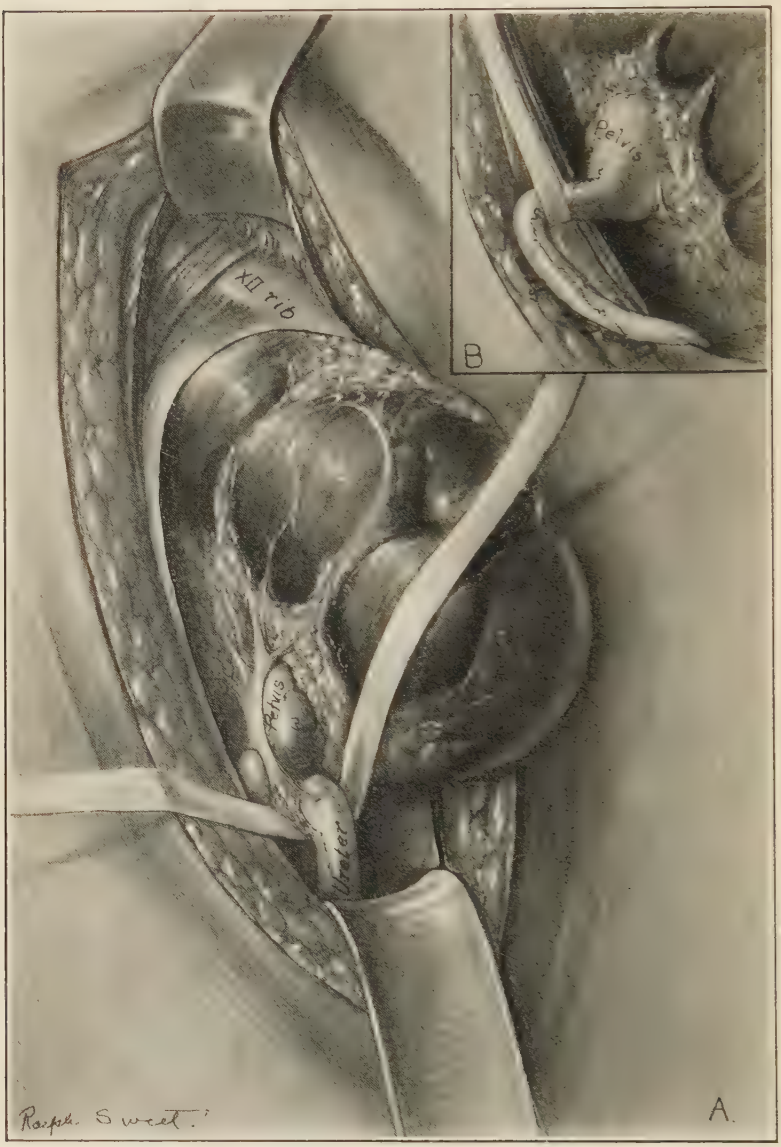


FIG. 231.—The kidney is shown partially separated from its surrounding tissues. A tape is passed under the ureter to facilitate its manipulation. The insert shows the appearance of the ureter and kidney pelvis when free. This exposure is utilized in performing pyelotomy. (Mathé.)

in such cases there is likely to be a stricture of some degree above it, which makes it impossible to dislocate it by manipulation. A stone so located will have to be removed through an incision in the renal pelvis made directly down upon it and a vertical incision across the constriction above the stone which will make an opening sufficiently large to permit its withdrawal. The angles of the wound so made are drawn together and sutured in such a way that a horizontal incision replaces the vertical one, and the constricted area of the ureter is dilated.

2. The stone may lie in a normal-sized pelvis, but the walls are rendered thick and indurated because of long-standing pyelitis. Under these conditions it will be necessary to obtain a good exposure of the pelvic walls, which can be accomplished by incising the fat capsule and the wall itself in a line parallel to the spines of the vertebræ, directly over the location of the stone. If there is no infection both wall and fat layer may be sutured separately and primary union obtained, but in the presence of infection, drainage will have to be introduced and special attention given to the ureter to see that it is not occluded, otherwise a urinary fistula may result. Sometimes a catheter may be left for a short time in the ureter.

3. If the stone lies at the junction of the renal pelvis and the ureter, but there is no constriction above it, even though the pelvis is considerably dilated, it can usually be dislocated by making an incision through the fat overlying the lower portion of the pelvis and pushing it upward. The fluid in the pelvis can then be aspirated and the stone taken out through a small incision in the wall of the pelvis, so that the trauma to the kidney proper is very slight indeed.

The presence of *infection* makes any of these procedures decidedly hazardous, and it requires considerable skill and judgment on the part of the surgeon to decide just what procedure is best suited to the needs of the individual case. In non-infected cases, the results have generally been satisfactory. If the pelvic incision can be closed by direct suture and a portion of the renal capsule turned over it or a covering made of fatty fascia, there will be less likelihood of urinary leakage, and better chance of primary union. The use of the fluoroscope, to which reference has several times been made, is of great assistance in preventing the oversight of small stones or fragments. It has been the practice of the authors to drain the pelvis with a soft rubber tube after pyelotomy and nephrotomy.

Enlarged Pyelotomy Incision.—It has recently been suggested[30] that in cases of large stone which cannot be delivered through the ordinary pyelotomy incision, nephrectomy may be avoided by retracting the parenchyma at the hilum, and isolating and double ligating the retropelvic artery. The original pyelotomy incision can then be enlarged in any direction necessary, either for the removal of a calculus, or for exploration of the calyces. Such an incision should be closed with interrupted fine chromic catgut sutures, and either peripelvic fat placed over the suture line, or a free transplant of fat taken

from the subcutaneous layer of the parietal incision. It is not necessary to approximate the cut edges of the renal parenchyma.

Operations upon the Hydronephrotic Kidney. Having removed the obstruction responsible for the production of hydronephrosis, be it an aberrant vessel, stricture of the ureter, or other cause of occlusion, it is the practice of many surgeons to follow the suggestion of Hinman and remove a large portion of the enlarged pelvis. The pelvis is then reconstructed in such a manner as to allow perfect drainage.

Partial Nephrectomy. When the patient's condition will not warrant the time necessary to enucleate the entire kidney, or an abscess or traumatic rupture has left viable kidney tissue which it is desirable to preserve, partial nephrectomy may sometimes be done. Under such conditions the capsule of the kidney is split, a plane of cleavage found, and the organ separated from its capsule in all directions. Arriving at the pedicle, the ureter can usually be separated from the mass of adhesions surrounding it and ligated, and when it has been divided a clamp can be applied to the pedicle. The most important consideration in a partial nephrectomy is the prevention of hemorrhage in the remaining portion of the kidney. The bleeding surfaces should be carefully sutured together, approximating the edges as far as possible. This same procedure is applicable to cases where traumatic rupture has taken place.

Nephrectomy in "Horseshoe Kidney."—A special application of partial nephrectomy is in dealing with a "horseshoe" kidney. Frequently the operator will have no knowledge of the existance of the anomaly until the regular incision has been made, but if the preliminary examination has revealed the conditions to be dealt with, the method of approach may be suited to the peculiar anatomical arrangements which will be encountered. Rovsing believes that the best approach to a fused kidney is through an anterior transperitoneal incision, because it enables the operator to see the isthmus uniting the two portions. This would be satisfactory in cases where there is no renal infection, but the chances of finding aseptic conditions are very small indeed, so that this plan is open to very serious objection. A feasible suggestion is the conversion of the usual posterior incision into a posterior lateral one, if necessary carrying the anterior limb farther back than usual, thus exposing the isthmus without opening the peritoneum.[47] All operations upon anomalous kidneys present more problems to the surgeon than similar procedures upon normal subjects. If thorough preliminary examination has not been made, and especially if the functional capacity of each side has not been established, the surgeon presented unexpectedly with a diseased fused kidney may be at a loss as to how to proceed. He must not run the chance of removing all the renal tissue in good working condition which the patient possesses, and it is frequently difficult, if not impossible, to ascertain the condition of the unexposed side, and even if the section before him is badly infected or full of stones, it may be fatal to remove it. A conservative pro-

cedure will be the only safe course to follow, even if it necessitates a second operation later on, when the function of the opposite side of the fused kidney has been demonstrated.

The structure of the isthmus will also have considerable bearing on the choice of procedure. If the connection between the two portions of the "horseshoe" is only a band of fibrous tissue, and the opposite side has been proved to be capable of carrying on sufficient renal function to maintain life, nephrectomy on the diseased side will present no more dangers than under ordinary conditions. But if the rare condition exists of the isthmus being made up in great part or entirely of functionating renal tissue, then we are dealing practically with a single kidney and the complications which follow partial nephrectomy, especially hemorrhage, will have to be reckoned with.

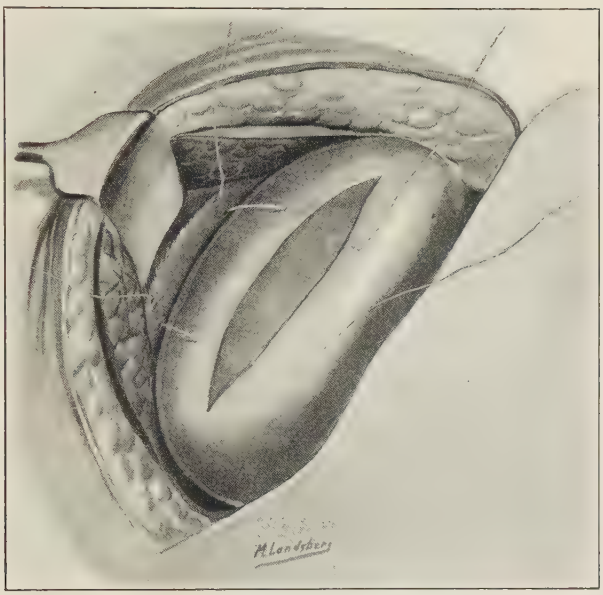


FIG. 232.—One method of fixing the kidney to the twelfth rib in doing a nephropexy. The kidney capsule is split and partially dissected back. The catgut sutures extend through the kidney substance and the periosteum of the twelfth rib, bringing the exposed kidney surface in contact with the periosteum.

Nephropexy.—The procedure by which the fixation of a mobile kidney is accomplished is called nephropexy or nephorrhaphy. The object of this operation is to so fix the kidney as to permit proper function of the ureter, and in uncomplicated cases this can be accomplished by stripping the kidney from its fatty envelope and placing it upon the proximal surface of the lumbar fascia. If in order to straighten the ureter, it is necessary to push the kidney so far back that it cannot be sutured in this way, it is best partially to decapsulate the back renal

wall, thus making it sure to adhere in its new position, a piece of fascia being then fastened over its lower end in order to hold it in place.

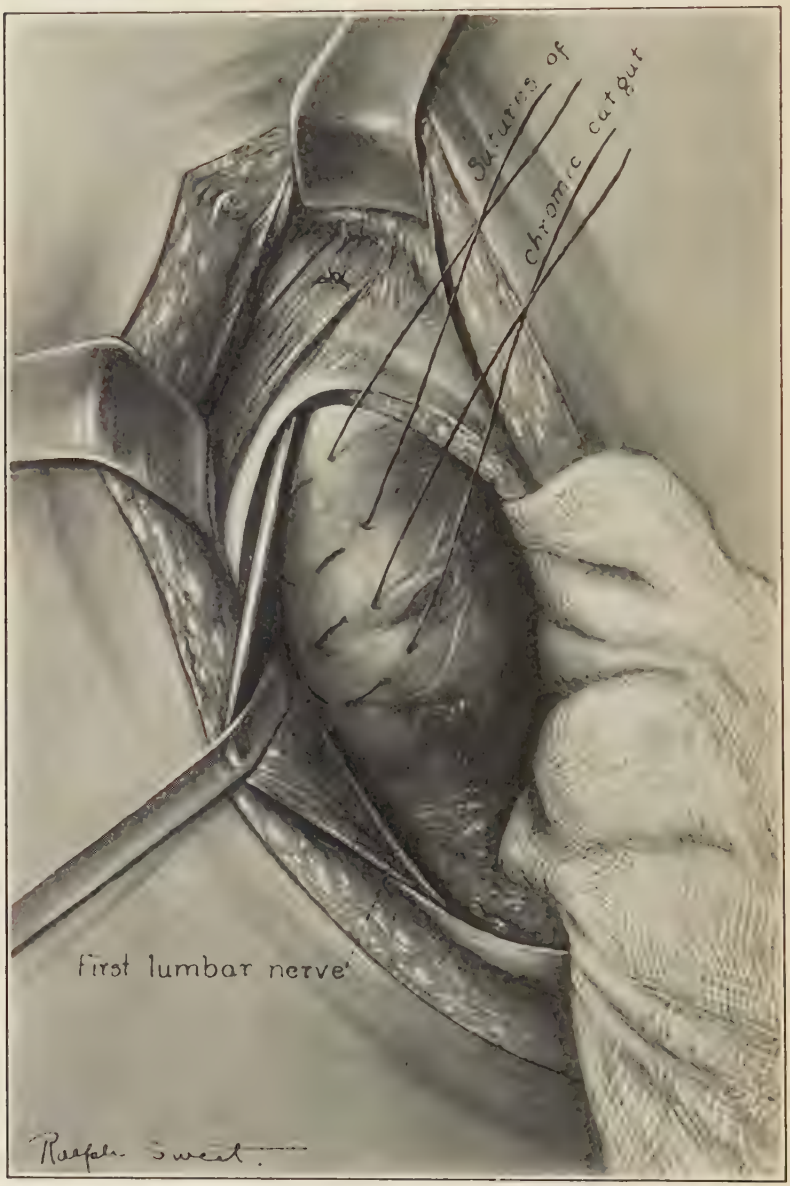


FIG. 233.—Another method of performing nephropexy is shown in the accompanying picture. The suture from the upper pole of the kidney is in place around the twelfth rib. Two sutures of chromic catgut are placed in the kidney, and are ready to be attached to the quadratus lumborum muscle. (Mathé.)

Splitting the capsule along the convex border over its upper half is another method which has found favor with many surgeons, from 2 to 6 square inches of the kidney surface being then exposed by means of a transverse incision both in front and behind, giving two large quadrangular flaps. A chromatized catgut suture is passed through the upper flap and carried just above the last rib, and the anterior and posterior flaps are then sewn by catgut sutures to the fascial wound or the quadratus lumborum muscle. The lower part of the fatty capsule is drawn to the upper angle of the fascial wound and fixed there, where it serves as a sling, holding the kidney as on a shelf and in its normal position.

Other pathological conditions are often associated with "floating kidney," tuberculosis and calculus being perhaps the most common, and these must, of course, receive consideration and proper treatment at the same time as the fixation is undertaken. Even psychotherapy may be necessary as an adjunct, for frequently surgery is impotent to remove the nervous symptoms which are coincident with it.

NON-OPERATIVE TREATMENT.

Irrigation.—The value of irrigation in certain types of renal infection is very highly rated by certain authorities. In pyelitis there is an acute inflammation of the mucous membrane, the congestion resulting in an exudate which produces pyuria and frequently, hematuria also. The edema caused by the inflammatory condition lessens the caliber of the ureter, or may even practically occlude it, and this in turn, reacts upon the kidney pelvis by promoting retention and dilatation.

When these conditions are present it is often surprising to observe the ameliorating effect which the mere passage of the ureteral catheter will have. Often nothing further is necessary to relieve the edematous condition of the urinary outlet and establish adequate drainage of the pelvis. Thus a single pelvic lavage, using any one of a half dozen antiseptics, often serves to clear up an apparently complicated condition.

Lavage of the Renal Pelvis.—A small catheter should be used, No. 5 is to be preferred in most cases, and none larger than No. 6 should be employed. The eye should be passed completely to the pelvis if possible. A 20 cc. syringe should be used and from 5 to 10 cc. of solution injected at a time, with pauses between injections to permit the escape of fluid. The solutions best suited for this purpose have been discussed elsewhere (page 532). If a relatively strong silver solution is employed, it is well to fill the bladder at least partially with saline solution, as it must be borne in mind that the vesical mucosa is much more sensitive to the action of silver salts than is that of the ureter and renal pelvis.

Chronic pyelitis responds well to pelvic irrigation, although in this condition there is usually no distention of the pelvis. If the inflam-

mation is of very long standing however, lavage of the pelvis will be of little benefit, if destruction of the renal parenchyma has already taken place.

As a *preparation for operation* for hydronephrosis or the removal of stone from a kidney known to be infected, pelvic irrigation may be of some service in rendering the field more aseptic. If the discharge of pus is so thick and abundant as to occlude the lumen of the catheter, it may be necessary to give repeated irrigations in order to establish free drainage.

The chief contraindication to pelvic lavage is the existence of tuberculosis, and it is also unwise to make use of it in calculus pyelitis, except as a preparation for operation.

Dilatation of the Ureter.—Dilatation of the ureter is often undertaken for the removal of small stones which can be dislocated by distention of the renal pelvis, and sometimes for the relief of hydronephrosis, when this is not very extensive. If the hydronephrotic condition has been induced by calculus obstruction it may sometimes be relieved in this way and operation thus avoided. In cases of mild pyonephrosis drainage of the affected area is occasionally undertaken by this route, but in the majority of cases nephrotomy offers a safer course.

Use of Tuberculin in Renal Tuberculosis.—The employment of tuberculin for diagnostic purposes has found a peculiar usefulness in tuberculosis of the kidney, as it represents the only method by which the existence of the lesion in the kidney can be established before the process is far advanced. During the last few years the possibility of renal tuberculosis has received much more consideration in attempting to make a diagnosis of obscure genito-urinary disturbances, but it is still overlooked in a great many cases and much valuable time is often wasted in fruitless treatment of cystitis or other results of the activity of the tubercle bacillus, which are wrongly attributed to some other cause. A diagnostic tuberculin test, properly applied, can do no harm even if the patient's frequency, urgency or bladder irritation are not the result of tubercular invasion, and if the reaction is positive, he has the inestimable advantage of being able to begin treatment early in the course of the disease.

Tuberculin therapy cannot be expected to abolish advanced tubercular processes where extensive destruction has already taken place, neither will it absorb a pus collection, if the condition is old enough to have permitted its formation. But when the patient's general condition is good, and there is reason to believe that little tissue damage has occurred, there is always a possibility of controlling the condition by tuberculin therapy, and even of avoiding operative measures entirely. Whiteside[91] recommends that very minute doses be given, making no attempt to reach the limit of tolerance and endeavoring to avoid any specific reaction.

Bilateral renal tuberculosis may often be benefited by the use of tuberculin and the patient's life considerably prolonged in those cases

where operation is out of the question. In some cases where one kidney has been removed, the administration of tuberculin has effected healing of associated lesions in the bladder and other parts of the uro-genital canal, and though too much must not be expected from it, there is no doubt that this therapy has its place as a most useful adjunct in the treatment of tuberculosis of the kidney.

Hypersusceptibility.—Without making any attempt to discuss the methods of administering tuberculin treatment, which each practitioner who desires to use this therapy must master for himself according to the particular therapeutic plan it is intended to pursue, it may be said in general that the hypersusceptibility of a patient in an early stage of renal tuberculosis with the infection localized in the kidney alone, corresponds to that of one suffering from a tubercular process in any closed gland.[10] When the disease is more advanced there are two distinct grades of hypersusceptibility. If the lesions in the kidney are active and extensive, with complicating vesical ulceration, the patient will be highly susceptible and treatment must be begun with very small doses. But when the process has advanced so far that the calyces are converted into sacs of caseous material and the entire kidney acts as a foreign body, its function being totally destroyed, there is likelihood of but little active inflammation, the tubercle bacilli found in the urine will be fungoid in character, and the persisting cystitis will be kept active by the irritation of acid urine and, in most cases, a superimposed mixed infection. Patients in this condition are fit subjects only for nephrectomy, and although susceptibility will be either very low or altogether absent, tuberculin therapy will be of no benefit.

The *real value of tuberculin therapy* lies in its ability to raise the natural defensive powers of the body.[37] Whenever this defensive power is normally sufficient to cope with the morbid process, the reinforcement it receives from tuberculin is useful; but if this natural power of defense is unable to overcome the tuberculous process, it is doubtful whether tuberculin can raise it to a point where it can effect a spontaneous cure. When tuberculin is presented as a curative agent, it may be eyed with suspicion; when as an adjunct to a normally conservative treatment, it should be welcome.

Other Vaccines.—The opinions held by urologists in regard to the usefulness of vaccine therapy in kidney affections, are widely at variance. At present there seems to be less enthusiasm regarding them than was in evidence some years ago. According to a large number of reports, excellent results have followed the use of both stock and autogenous vaccines in acute and subacute colon bacillus infections, but in chronic pyelitis and pyelonephritis, they have, according to general report, proved of no value, neither preventing exacerbations nor diminishing the amount of pus or bacteria present in the urine. Probably autogonococcic serum might be useful in the treatment of gonococcal infection of the kidney, but in the scanty literature upon this

subject we have found nothing concerning this, though Hagner treated his patient with bacterin.[40]

Bacteria in the urine may be lessened in number by the administration of urinary antiseptics which render it a less favorable medium for the cultivation and development of organisms. The whole question of urinary antiseptics has been carefully studied by Hinman,[48] and more recently by other investigators including Young, Veder Leonard and Henline.

Disinfectants.—Treatment by disinfectants may be external or internal. The properties required of a substance in order to give satisfactory external disinfection are a germicidal power which will kill the organism in the limit of time of exposure and with this, stability of chemical structure, penetrating action, but neither toxic nor irritating action. *No such ideal substance is known.* Because of this lack, clinicians have come to rely on strong inhibitory substances for external use. An internal antiseptic, which will give constant inhibitory effect, will be more efficient than an indifferent external germicide used periodically.

Hexamethylenamine is very efficient in a large number of cases, but it has definite limitations. It is of value only by virtue of its conversion into formaldehyde which takes place gradually in an acid urine. The alkalinity of the urine in infections which produce decomposition of the urea cannot in the majority of cases be changed by feeding acid-producing drugs. The necessity of concentration and time for the accumulation of formaldehyde in antiseptic amount largely destroy the value of the drug for kidney antisepsis, except in some cases of hydronephrosis; for bladder antisepsis in cases with polyuria or frequent urination, except when retention in some form is present; in cases of urinary fistula, notably postoperative prostatics during the period of incontinence, and in cases with continual bladder drainage as in true incontinence or with retention catheter; and for urethral antisepsis no matter what the infection. The greatest usefulness of hexamethylenamine is in bladder prophylaxis, in cases in which the above urinary conditions are not present.

Basic Dyes.—A study of the selective antiseptic action of some basic dye stuffs, their stability and penetrating action, the innocuous nature of many, and the known proclivity of the kidneys for their excretion, emphasize the future importance of such substances as internal urinary antiseptics. The bacteriological findings with some of the substituted compounds of the rosanilin group indicate their possible application in the treatment of colon bacillus infections of the urinary tract. The selective action toward tuberculous lesions of trypan red and allied dyes opens up an interesting field for their therapeutic application.

Methylene blue in a dilution of 1 to 150,000 will inhibit the growth of staphylococci. It is diffusible and relatively non-toxic, but only about one-half of the amount ingested is eliminated by the kidneys, and of this some is frequently in the form of inactive split-end products. The

absence of a deep blue urine indicates imperfect antisepsis, which may be due to this metabolic decomposition, or to a delayed or deficient excretion as the result of renal disease, in which case continued use of the dye may cause severe renal injury. In the presence of urinary infection bacteria themselves may decompose the dye into these inactive chromogens. Formaldehyde tends to reconvert these less basic, leuko-derivatives into the original right-spectral dye, therefore, hexamethylenamine may often be advantageously given with methylene blue in these cases of bacterial decomposition of the dye; but the urine must be acid and in most of these cases there is an associated bacterial decomposition of urea which makes the urine alkaline. Doses of from 3 to 6 grains may be given four times a day for several days, when it is advisable to discontinue its use for a few days. The ability of staphylococci to adapt themselves to the presence of the dye shows the need of finding a substitute so that the two may be used alternately. The dye is of particular value in renal or bladder infections due to the staphylococcus, but is valueless in pure urethritis from whatever cause. The great objection to its use is its disagreeable staining properties.

Other Medication.—The value of internal urinary antiseptics of other substances such as salol, sandalwood oil, salicylic, boric and benzoic acids, is very limited. Recently Young has advocated the use of mercurochrome administered intravenously as a cure for infections of the urinary tract, as well as infections of the blood stream. It is too early to decide whether this form of therapy will be effective. Veder Leonard has advocated the use of hexylresorcinol taken by mouth as a urinary antiseptic. Our brief experience with it leads us to believe that when it is properly administered it is very effective in the treatment of patients suffering from *Staphylococcus aureus* infection of the urinary organs. It seems to be more effective than hexamethylenamine in the treatment of disease caused by the colon type of organism. In regard to the use of this drug, it is also too early to draw definite conclusions as to its permanent value as a urinary antiseptic.

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